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1960 Annual Report

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LAKE STATES FOREST
EXPERIMENT STATION

LAKE STATES
FOREST EXPERIMENT STATION
St. Paul 1, Minnesota

M. B. Dickerman, Director

FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
1961

The Station is maintained in cooperation with the University of Minnesota

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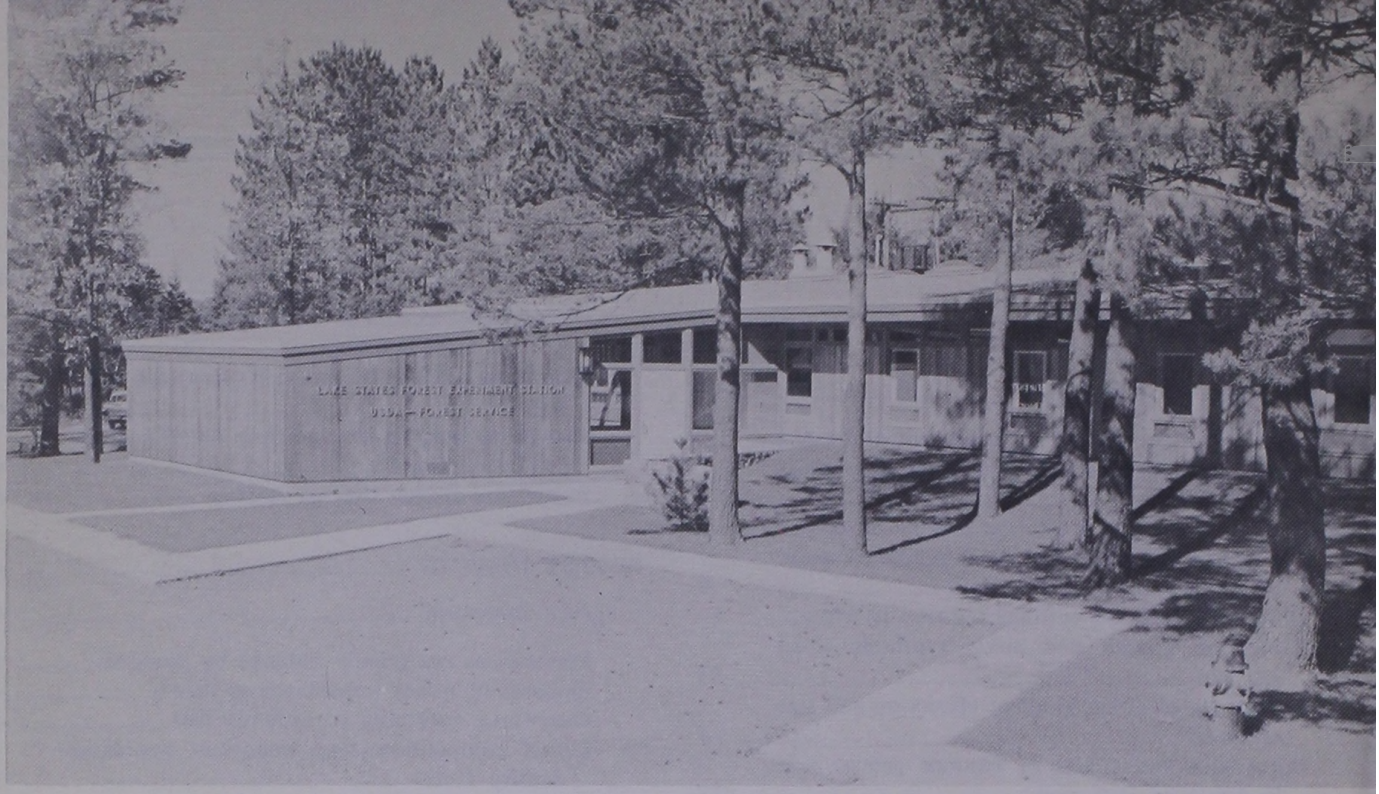
LAKE STATES FOREST EXPERIMENT STATION
USDA—FOREST SERVICE

THE YEAR IN REVIEW

M. B. DICKERMAN, *Director*

"The forest and its relation to streams and inland vegetation; to water power and flood control; to the soil and its erosion; to coal and oil and other minerals; to fish and game; and many another possible use or waste of natural resources— . . . here were not isolated and separate problems . . . here was one single question with many parts . . . Conservation of natural resources . . . is the key to the safety and prosperity of the American people."

These were thoughts of Gifford Pinchot more than 50 years ago as he was riding along a trail in Washington's Rock Creek Park. Through him and others who followed, national emphasis has been on translating these concepts into action. Passage of the Multiple Use Law by the Congress in 1960 added recent implementation and direction to national purpose in forest conservation.

As we move along in the sixties, the evidence becomes stronger and stronger that research is essential to progress. Consequently, this past year, the Station's planning staff has been largely occupied with developing ideas and methods for accomplishing the research part of the National Forest Program for the Lake States area. Its attention has been devoted primarily to program selection, emphasizing basic research, with consideration of the staff and facilities needed to execute it effectively.

Considerable progress has already been made in this direction. The assignments of the field units have been clarified. Additional fundamental research has been started in several fields of study. Two new laboratory research buildings were completed in 1960, and plans for another are on the drawing board. A new experimental forest was dedicated at La Crosse, Wis.

FIGURE 1 (on opposite page).—Dedication day at the new laboratory of the Grand Rapids, Minn., field unit. *Top*, the new building. *Middle*, from left to right, M. M. Nelson, regional forester, Milwaukee; M. B. Dickerman, Director, Lake States Forest Experiment Station; Dr. R. E. McArdle, Chief, U. S. Forest Service; Clarence Prout, Deputy Commissioner, Minnesota Department of Conservation: and Dr. Harold Macy, Dean, Institute of Agriculture, University of Minnesota. *Bottom*, left to right, Z. A. Zasada, leader of the Grand Rapids field unit; L. P. Neff, Supervisor, Superior National Forest; J. H. von Bargen, Supervisor, Chippewa National Forest; Dr. R. E. McArdle, Chief, U. S. Forest Service; and M. B. Dickerman, Director, Lake States Station.

One of the new laboratories (fig. 1) is at Grand Rapids, Minn., where research is conducted in the management of northern conifers and in the hydrology of swamps and bogs in northern forests.

The other, at Rhinelander, Wis., is devoted to genetics (fig. 2). Through selection and hybridization, through breeding of disease- and insect-resistance strains, the objective is to substantially improve the quality and yield of northern conifers and hardwoods. Likewise, hardiness in planting materials for the Northern Great Plains is another objective of genetics research.

Funds were appropriated by Congress in 1960 for a laboratory at Marquette, Mich. Management studies of northern hardwoods are to be concentrated here. Plans for this building are completed, and it should be ready for occupancy in 1961.

The Coulee Experimental Forest near La Crosse, Wis., was dedicated in June 1960. Here the relationship of vegetative cover on forest land to runoff and erosion is to be studied.

In all these activities, stress is being placed on providing more adequate scientific equipment so necessary for fundamental forestry research, especially in insects, diseases, soils, plant physiology, and genetics.

Recreational uses of forest land was the subject for a new area of research in the Station program in 1960. Robert Lucas, a social scientist, was added to the staff to give impetus to research in forest recreation. Our initial effort is concentrated on recreational questions covering the Boundary Waters Canoe Area. During 1961, additional studies in recreation will be undertaken—all pointing toward developing an understanding of the recreational interests and needs of people now coming into the forests of the northern Lake States.

Wildlife habitat problems were recognized too. An ecologist, Dr. Forest Stearns, is coming to the

FIGURE 2

Station to work in the area of wild-land management. Emphasis will be placed on the integration of wildlife habitat and timber management. This is a field which urgently needs greater attention.

Fire studies have been neglected in recent years because of the lack of funds and personnel. Problems of recruiting competent leadership were overcome with the transfer of John H. Dieterich from the Northern Forest Fire Laboratory at Missoula, Mont., to the Lake States Station. Mr. Dieterich has had 8 years' experience, much of it on studies of coniferous slash inflammability. Now that we have the leadership, it is essential that adequate financing of fire research be available in the near future.

Research on established projects has been continuing at the Station at an accelerated pace. A bird's-eye view of accomplishments in 1960 can be obtained by scanning the titles of the 80 publications listed at the back of the report. Among the more comprehensive reports which summarize Station studies are "The Larch Sawfly: Its Biology and Control," by Drooz; "How to Release Conifers with Chemicals," by Arend and Roe; "Factors Important to Yellow Birch Establishment in Upper Michigan," by Godman; and "Michigan's Forest Resources," by Findell, Pfeifer, Horn, and Tubbs.

The last-named is the product of a cooperative forest survey conducted by the Station and the Michigan Department of Conservation, with participation by other public agencies and forest industries. It is an example of the increasing amount of cooperation now existing among many forest research organizations.

An important phase of the work of any forest research group is discussing with other research workers, forest owners, and forest managers the results of investigations through conferences, consultations, and demonstration tours. One of the Station's field units, for example, conducted tours of experimental areas for over 250 visitors during 1960.

FIGURE 2.—The new laboratory building at the Northern Institute of Forest Genetics was dedicated in September 1960. Main speaker was Dr. Paul Kramer (center), Head, Department of Botany, Duke University. Brief remarks were also made by: (Top left to right) M. B. Dickerman, Director, Lake States Forest Experiment Station; Dr. George M. Jemison, Deputy Assistant Chief, U. S. Forest Service; Hon. Alvin E. O'Konski, Member of Congress; (middle row l. to r.) E. J. Wittock, Mayor of Rhinelander; L. P. Voigt, Director, Wisconsin Conservation Department; and C. N. Nelson, State Forester, State of North Dakota; (bottom, l. to r.) Dr. R. K. Froker, Dean and Director, College of Agriculture, University of Wisconsin; and Folke Becker, President, Trees for Tomorrow. In the background picture at top left is Dr. Hans Nienstaedt (at right of group of three men). Nienstaedt is the geneticist in charge of the Institute.

The greater share of these were practicing foresters from industry, and from Federal, State, and county agencies. An increasing number are coming from Canada and Europe.

An interesting variation on show-me trips, in which the Station took a prominent part, was a week-long tour of the Lake States by 46 foresters representing 15 foreign countries. Previously these foresters had attended the Fifth World Forestry Congress at Seattle, Wash. Stops on the tour included wood-using industries, a tree nursery, a fire equipment demonstration, examples of timber harvesting equipment, research in forest management and utilization, forestry schools, and the Forest Products Laboratory.

The training and ability of scientists employed by the Station largely determines the quality of the research. Currently, 18 staff members are engaged in graduate programs. Others have recently completed the prerequisites for their doctoral degrees. Adjusted workweeks, part-time work, and use of the authority granted by the Federal training act are incentives provided by the Station to encourage further training.

A research program is affected by many factors in addition to personnel, facilities, and funds. The timber, water, wildlife, and recreational resources are continually changing, as well as the economic conditions of an area. Research results frequently suggest new and fertile fields of study, as well as problems. Some of the places where our program needs reinforcement, and for which plans are under consideration, follow.

Of deep concern to the Station are the depressed areas in the northern Lake States. The supply of labor and of certain kinds of timber makes the Lake States a highly desirable region for the further development of wood industries, of recreation, and of wildlife. Greater emphasis on research in forest engineering and timber utilization could lead to a speeding up of economic development and greater employment.

Insects continue to cause serious losses of timber. Scientific investigation on the spruce budworm indicates that more intensive work must be done on the prevention or limitation of defoliation through biological control — parasites and diseases — and through silvicultural practices.

The rapidly increasing area of coniferous plantations and their steady growth toward maturity obviously point to management problems, especially in the field of tree nutrition.

Watershed studies already initiated in the northern swamps and bogs suggest possibilities of increasing the quality and quantity of water from these tracts.

Strengthening of recreation, wildlife habitat, and fire research could add rapidly to the fund of knowledge so essential to developing effective policies for multiple use of the vast forested area in the Lake States.

In the subsequent sections of this report, each of the Station's technical Divisions describes its work. A few of the studies underway are discussed. Some were selected because they are new, others because significant results can be reported. Additional information on these and other studies is available on request.

January 15, 1965

To: St. Paul Employees

From: K. W. McNasser

Each of us is genuinely concerned about Zig Zasada's progress at St. Barnabas Hospital.

On Friday morning, January 15, a preliminary diagnosis indicates the possibility of a digestive tract ulcer. Realizing the desire of a lot of us to "cheer him up," Mrs. Zasada has asked that we do not visit Zig until he has had a chance to rest up for a few days.

We'll be sure to let you know when visitors will be more helpful than tiring. In the meantime Zig will know that we are all bucking for his fast return to genial good health.

K. W. M.

FOREST MANAGEMENT

ROBERT D. MCCULLEY, *Division Chief*

The work summarized in this report is made up of projects that either were completed or reached a significant stage of development during the year. By nature, research in forest management includes a large proportion of field plot experiments which yield information from successive remeasurements over long periods of time. The investment in these plots was strengthened during the year, thus providing a more complete basic framework for development of silvicultural information in the important coniferous and hardwood timber types.

Within the limitations of available facilities the Station has for a long time conducted research on silvical requirements of the important tree species. The development of improved laboratory facilities means that more effective research on some of the fundamentals of tree growth can now be done. The space in this report devoted to results of projects in which laboratory facilities played an important part indicates their influence on program development.

The emphasis on tree improvement and genetics research increased during the year. This is in line with long-term goals that recognize the importance of upgrading the growing stock to put forest lands of the Lake States in more productive condition. Such a development is necessary to supply projected demands for wood products in the years ahead. A continued strengthening of this phase of the Station's research is expected.

Boxelder Blight Related to Weed-Control Spraying

A growth deformation of boxelder seedlings being grown for windbreak planting in North Dakota has been under investigation at the field center at Bottineau for the past 2 years. Apparent association of the blight with aerial spraying of agricultural weedicides was checked in a series of tests. Evidence is fairly conclusive that the blight is caused by drift from these spraying operations during the early part of the growing season.

The sensitivity of boxelder leaves to 2,4-D was determined to be extremely high. Leaf modification is induced by applications of as little as 0.1 microgram. The abnormal growth resulting from such an application has the same appearance as that on seedlings observed in the nursery and on larger plants established in field windbreaks.

To test presence of herbicide drift in the nursery, two indicator plants were grown in alternate rows with boxelder seedlings. These plants are cotton and grape. In other research they have been found to be very sensitive to minute dosages of 2,4-D. The leaf deformation which results from their exposure to the herbicide can be readily determined in the field. In the test, the predisposition of the very young leaves to develop symptoms, the duration of the sensitive period, and the time of resumption of normal growth were the same for the indicators and boxelder (fig. 3).

The final phase of the study dealt with extracts from deformed leaves of boxelder. The presence of a growth inhibitor in this extract was determined by tests of root repression in cucumber seedlings. Application of the extract to the foliage of healthy cotton and boxelder seedlings produced blight symptoms in both. An extract was made from boxelder leaves that developed late in the growing season after blight symptoms were no longer evident. When this extract was applied to the foliage of healthy seedlings, near-normal growth resulted.

The results of this study have substantiated the opinion that spraying of 2,4-D for weed control is responsible for deformation of new growth of boxelder. Production of boxelder stock for windbreak planting has been discontinued because of the blight. The loss of this species, which is hardy under the demanding conditions for growth in the northern plains, has reduced the already limited number of well-adapted species available to tree planting agencies. But it seems evident that boxelder should not be planted in agricultural areas so long as 2,4-D is in common use as a weedicide spray.

FIGURE 3.—Deformation of the foliage of indicator plants and boxelder grown in the Bottineau, N. Dak., nursery. *A*, cotton; *B*, boxelder; *C*, grape.

Sugar Maple Sprouting Affected under Some Stand Conditions

Sugar maple is no exception to the rule that most hardwoods sprout readily. Hardwoods may be successfully managed for maximum volume production over short rotations by depending upon sprout reproduction. In the northern Lake States, however, the value of sugar maple lies in its utilization for lumber and veneer. In such stands, sprout reproduction is less desirable than higher quality seedling reproduction.

Information about the factors that influence the sprouting of sugar maple has been meager. A knowledge of the effects of stand density and stump diameter on the production of sprouts and the rate of sprout growth would aid in the management of sugar maple stands for high-quality products.

Accordingly, our Marquette field center has made tests of sugar maple sprouting vigor, sprout height growth, and survival 2 and 5 years after stands were cut. Stumps were studied in old-growth sawtimber, mixed second-growth sawtimber and poletimber, and young poletimber stands.

In the old-growth stand, the original basal area of 110 square feet per acre was reduced to residual densities of either 30, 50, 70, or 90 square feet. The basal area of the mixed sawtimber and poletimber stand, originally the same as that of the old-growth stand, was cut to give densities of 40, 60, 80, and 100 square feet. The poletimber stand had a basal area of 85 square feet before treatment; one portion was thinned from below to 50 square feet, using a 6-inch maximum diameter limit; the other portion was cut from above to 70 square feet, applying a 12-inch minimum diameter limit.

The percentage of stumps with sprouts in the old-growth stand decreased significantly with an increase in stump diameter, residual stand density, and years since cutting (fig. 4). A multiple regression equation was developed to express each of these factors in

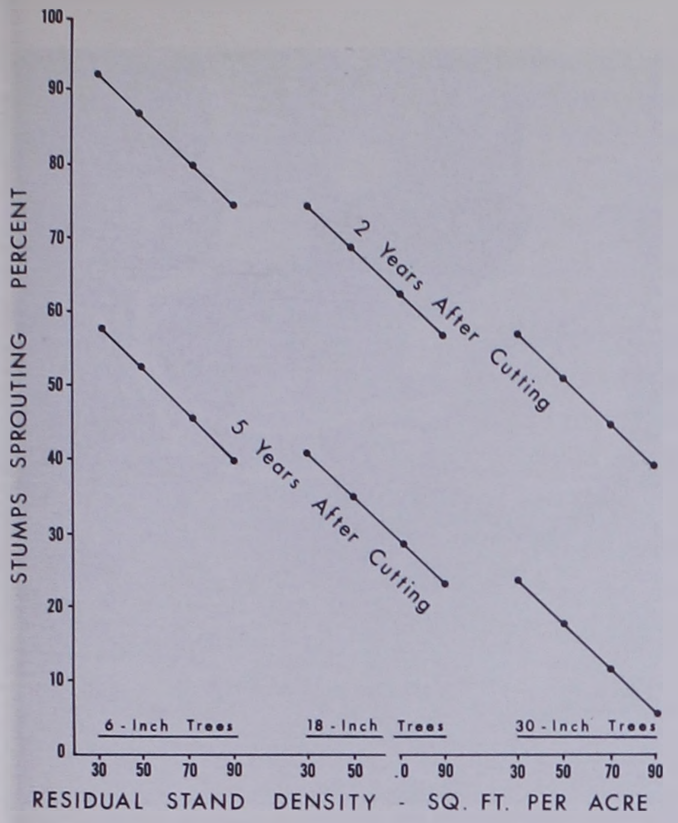

FIGURE 4.—Relative effect of stand density, tree diameter (inches at breast height), and years since cutting on the percentage of old-growth sugar maple stumps with living sprouts.

terms of influence upon percentage of stumps with sprouts. The number of sprouts per stump also declined as stump diameter and years since cutting increased. The height of the dominant sprout on each stump was related only to the number of years since cutting. The average height at the end of 5 years after cutting was only 4.0 feet, indicating that sprouts from large old-growth stumps do not grow vigorously.

In the second-growth stand the effect of years since cutting had about the same influence upon percentage of stumps with sprouts as in the old-growth stand, but sprouting capacity did not decline with increasing tree size and stand density as it did in the old-growth stand. At the end of the fourth year about 40 percent of the stumps had sprouts. At the end of 5 years the height of the average dominant sprout in the second-growth stand was equal to that in the old-growth stand. However, heavy deer browsing in the second-growth stand is the major reason why the percentage of stumps sprouting and sprout height were not superior to those in the old-growth stand.

Sprouting was more vigorous in the poletimber stands than it was in the second-growth and old-growth stands. Three years after the cut, 91 percent of the stumps had sprouts; average height of sprouts was 4.8 feet. In the stand thinned from below, tree size had no significant effect on the percentage of stumps sprouting, the number of sprouts per stump, or the height of the dominant sprout. However, the stumps were all from trees less than 6.5 inches d.b.h., and no deer browsing was observed. In the same stand thinned from above, relatively few trees were cut, and those largely rough individuals of other species than sugar maple. However, the percentage of stumps with sprouts and the number of sprouts per stump were slightly less than for the stand thinned from below.

Quaking Aspen Site Prediction Scheme Developed

In the past 15 years quaking aspen has changed in status from a species of little commercial value to the leading pulpwood species of the Lake States. With this increase in commercial importance, the need for better silvical information for management of the extensive aspen stands of the area has grown. Specific information on soil-site relationships, the influence of edaphic and topographic factors on the growth of quaking aspen, is one area in which foresters have often sought information from research. Consequently, an evaluation was made of factors that influence quaking aspen growth in northern Minnesota in areas supporting extensive commercial stands of the species. This study, conducted in cooperation with the Office of Iron Range Resources and Rehabilitation, was aimed at developing relatively simple techniques whereby a practicing forester might rate land for production of quaking aspen regardless of the present type of vegetation now occupying the site.

A review of the literature on the subject was first made to determine the factors that, in relatively limited or local studies, had been shown to be of importance in quaking aspen growth. This review was subsequently published as Station Paper 32. The factors selected for use were soil characteristics, topographic features, and fire history of the stand. Soil characteristics measured were percentage of silt-plus-clay and percentage of stoniess of the upper 36 inches of soil, the silt-plus-clay content of the subsoil, pH of the subsoil, and the depth to hardpan

and to mottling if present (figs. 5 and 6). These features were determined with simple field equipment such as might be used by practicing foresters.

FIGURE 5.—Rudolph Strothmann determining the silt-plus-clay content of the soil by means of a Cenco-Wilde soil colloid testing kit.

A soil pit was dug to a depth of 3 feet on each plot, with deep sampling by auger to determine if the water table was within 6 feet of the surface. Topographic features recorded were percentage of slope, the aspect, and the position of the plot on the slope.

Fire history of the plots was classified in one of three categories:

1. Favorable—no fires since stand establishment, and only one moderate-to-heavy burn prior to establishment.
2. Somewhat damaging—no fires since establishment, but heavy or repeat burns prior to establishment.
3. Very damaging — fires both before and after establishment.

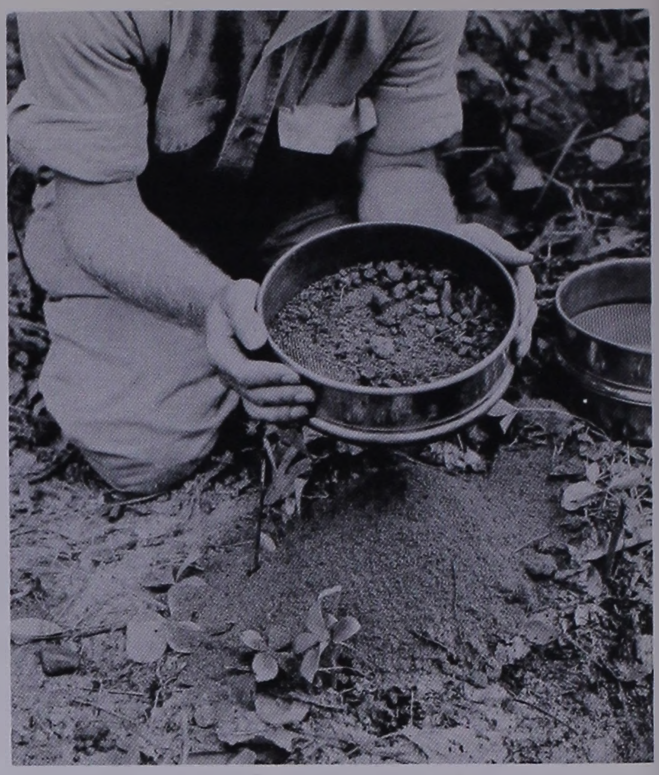

FIGURE 6.—Determining the percent stoniess of the soil (particles larger than 2 mm.) by screening a representative soil sample.

Areas that show no evidence of ever having burned but are now in quaking aspen are not common; these were placed in category 1 when encountered. Fire history had to be determined by circumstantial evidence, which might in some cases be interpreted differently by different observers.

The study included measurements on 257 plots, 22 of which were exploratory, during the seasons of 1954, 1955, and 1956. To insure good geographic coverage of the complex geological area and climatic variation in northern Minnesota, plots were allocated on the basis of county size and the relative importance of the quaking aspen type in the county.

A wide range of site quality was found in northern Minnesota from a high site index of 97 feet to a low of 43 feet. Development of a good scheme for predicting site quality solely on the pasis of site factors proved to be more difficult than recognizing, through the height of existing stands, that variations in site quality existed. Table 1 rates topographic factors in three quality classes; table 2 rates soil quality for quaking aspen growth in four classes. These broad groups were selected to give a reasonable number of classes that could be handled easily in the field; furthermore, inability to pinpoint site

quality closely by the scheme made more classes impractical. Table 3 combines the classes of tables 1 and 2 to give the range and average of site index values for the edaphic and topographic classes established.

The large range of site index values within some classes is attributed to the existence of important factors influencing site quality that were not tested in the study and to the crudeness of the techniques that were used in an effort to duplicate those methods that might be applied by potential users.

TABLE 1.—*Rating of topographic factors [1] influencing aspen growth in northern Minnesota*

Slope (percent)	Aspect	Topographic position	Topography rating
5 - 20	S and SW	Lower slope	Average
		Upper and middle slope	Unfavorable
	W,NW,N,NE,E,SE	Lower slope	Favorable
		Upper and middle slope	Average
21 or more	S and SW	Lower slope	Unfavorable
		Upper and middle slope	Unfavorable
	W,NW,N,NE,E,SE	Lower slope	Average
		Upper and middle slope	Unfavorable
----	----	Depression	Average
----	----	Ridgetop	Unfavorable

[1] Land with less than 5-percent slope, other than depressions or ridgetops, was considered as flat and hence without slope, aspect, or position.

TABLE 2.—*Rating of soil factors influencing aspen growth in northern Minnesota*

Percent of stoniness in upper 36 inches of soil	Percent silt + clay content of upper 36 inches of soil, and water table relationships	pH of subsoil	Soil rating
0 - 30	0 - 9 (w.t. below 60 inches)	Any	Poor
	0 - 9 (w.t. 0-60 inches)	Any	Fair
	10 - 20	Any	Fair
	21 - 30	Any	Good
	31+ (w.t. 0-24 inches)	Any	Good
	31+ (w.t. below 24 inches)	6.9 or less	Good
	31+ (w.t. below 24 inches)	7.0 or more	Excellent
31 or more	0 - 9 (w.t. below 60 inches)	Any	Poor
	0 - 9 (w.t. 0-60 inches)	Any	Fair
	10 - 20	Any	Fair
	21 - 30	Any	Fair
	31+ (regardless of w.t.)	Any	Good

The complex pattern of landforms, glacial drifts, and soil types that support quaking aspen stands in northern Minnesota no doubt also contributes to the errors of estimate, but no consistent relationship to these features could be determined from the data available.

TABLE 3.—*Aspen site prediction scheme combining soil and topography ratings (based on 235 plots)*

Topography rating [1]	Soil rating [2]	Site index			No. of plots
		Average	Highest	Lowest	
On sloping land:					
Favorable	Excellent	86	90	83	2
	Good	78	97	59	13
	Fair	74	74	74	1
	Poor	([3])	([3])	([3])	0
Average	Excellent	76	85	60	7
	Good	69	77	57	12
	Fair	66	87	52	10
	Poor	([3])	([3])	([3])	0
Unfavorable	Excellent	72	79	68	3
	Good	68	76	61	10
	Fair	59	72	50	4
	Poor	44	45	43	2
On flat land: [4]					
	Excellent	74	90	57	63
	Good	70	91	57	46
	Fair	66	82	53	52
	Poor	57	70	50	10

[1] See table 1 for descriptions of topography ratings.
[2] See table 2 for descriptions of soil ratings.
[3] No data were obtained in these categories.
[4] Having slope of less than 5 percent.

Northern Conifer Planting Stock Produced Under Long Photoperiods in Florida [1]

Planting of nursery-raised stock is now the most reliable and the most economical method of reforesting the Lake States. Although an estimated 1½ million acres have been reforested successfully by planting in the Lake States, millions of acres of former forest land remain to be planted. The trend in tree planting has been upward in the past decade, reaching 122,000 acres in 1959. Planting will remain an important forest activity for many years to come.

A high proportion of the trees raised for planting are kept in the nursery for 3 or 4 years, with the last 1 or 2 years in widely spaced rows in transplant beds. Although some nurseries have produced satisfactory stock without transplanting, transplant stock still has proved desirable on most planting areas. Reducing the length of time needed to produce planting stock would lower production costs and consequently the costs of reforesting forest land.

The longer frost-free growing season farther south should be favorable for northern species. However, they have been adapted through evolutionary processes to the long photoperiod of northern latitudes during the growing season. Consequently they are

[1] Study conducted in cooperation with the School of Forestry, University of Minnesota.

usually stunted when grown in more southern areas where the photoperiod is short. A combination of an artificially lengthened day through low-intensity incandescent illumination and the long frost-free season of lower latitudes should offer the advantages of both. Complicating factors are the unusual temperatures and unfamiliar indigenous biotic influences.

The nursery at the Olustee Experimental Forest in northern Florida was selected for a small test of the growth of white and red pine and white and black spruce under an extended photoperiod of 20 hours as well as the natural photoperiod in this region. The growing season here is approximately 265 days compared with about 125 days in central Wisconsin. The personnel of the Southeastern Forest Experiment Station at Olustee generously cooperated in the experiments. The seedbeds were sterilized with methyl bromide before planting, a standardized local practice to protect the seedlings against fungi and nematodes. Duff from a northern conifer stand was then worked into the beds to provide inoculum of mycorrhizal fungi, and the beds were seeded. The seed was from stand collections selected to minimize genetic variability. Fifty-percent shade was used the first season, 30 percent the second, to provide protection against excessive insolation. Fertilization was based upon local experience with native species, augmented by analysis of the nursery soil.

A similar installation was established in the Hugo Sauer Nursery, Rhinelander, Wis., in beds made available by the Wisconsin Conservation Department. Natural and 20-hour photoperiods were used.

Survival proved to be a serious problem in Florida. Treatments tried were: fungicides early in the season to combat what appeared to be root rots; wide-spectrum fertilization, including minor elements, because of the poor sandy soil of the nursery (subsequent greenhouse experiments indicated that nutrient deficiences were not the cause of mortality); and nematocides to destroy parasitic nematodes discovered in the beds in midsummer. None of these treatments eliminated progressive mortality during the first season.

At the beginning of the second season, a second group of beds was formed several inches above the general nursery level, and provided with draintile to lead off the excess water from the occasional torrential rains. Survival has been excellent in this bed during the two growing seasons that it has been in use.

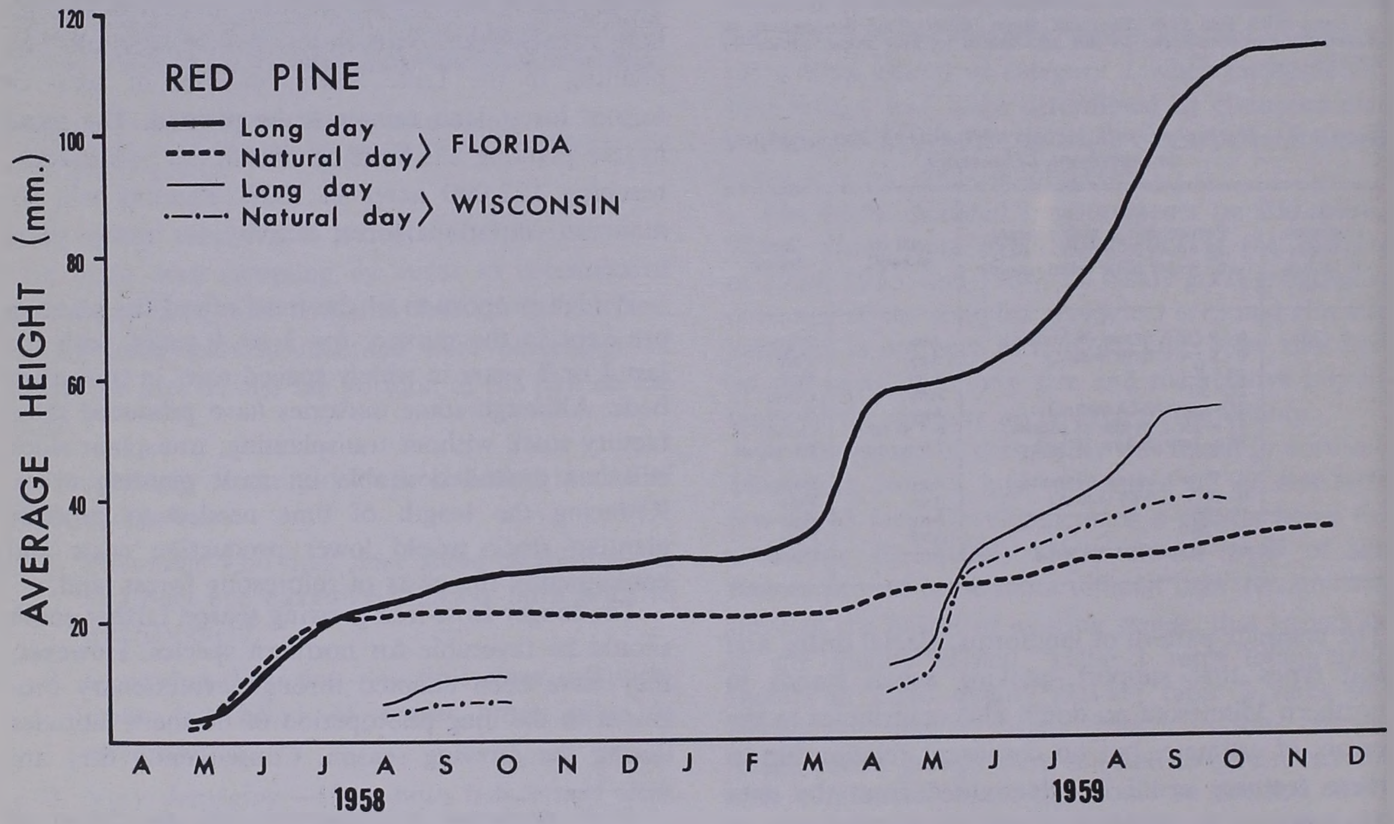

FIGURE 7.—Red pine: average height in Florida and Wisconsin from cotyledons to growing tip.

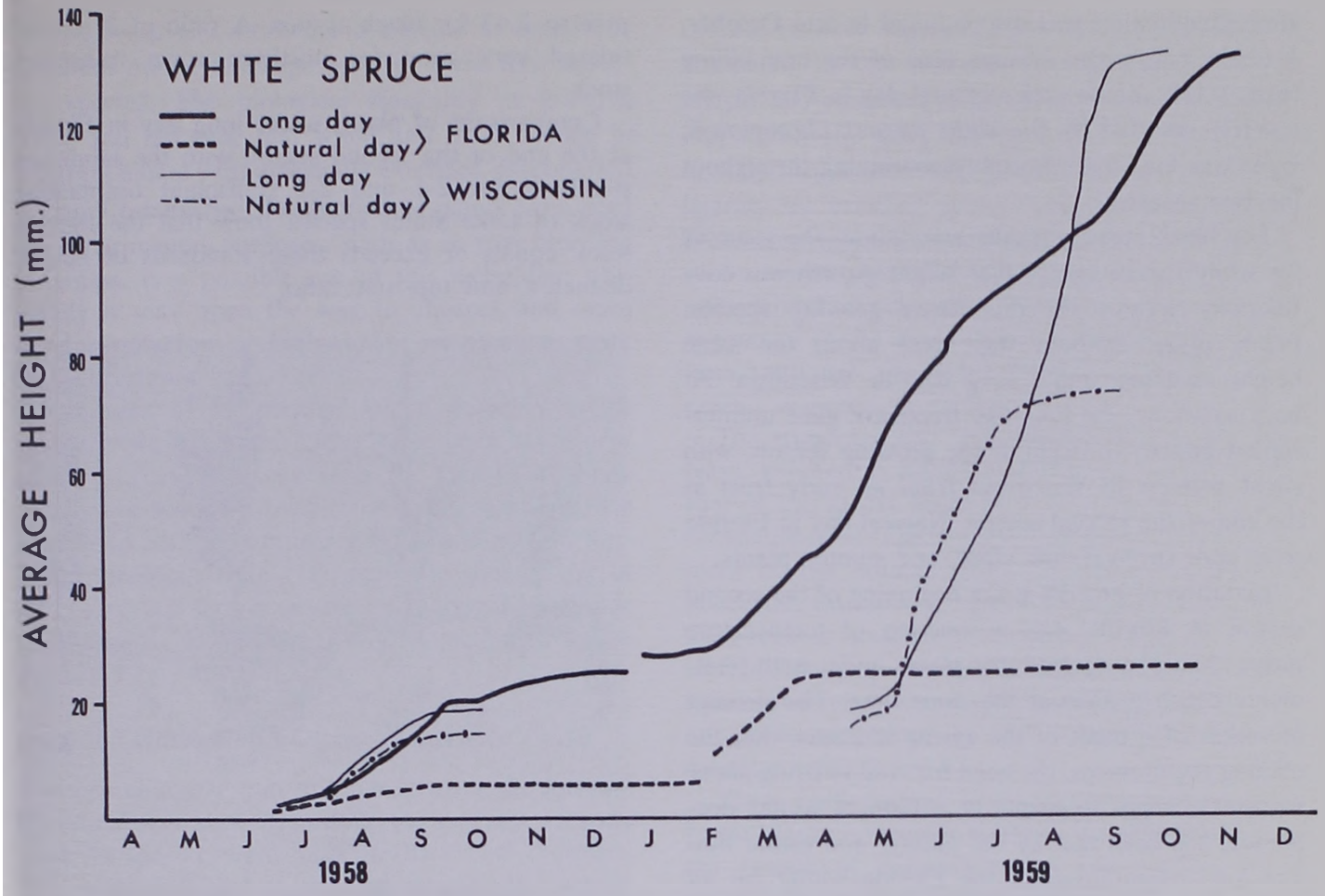

FIGURE 8.—White spruce: average height in Florida and Wisconsin from cotyledons to growing tip.

Despite the less-than-optimum growing conditions of the initial planting in Florida, growth of the plants under long day has been encouraging. Figures 7 and 8 show the trend of average height for red pine and white spruce under both treatments in Wisconsin and Florida for two seasons.

At the end of the second growing season, red pine under long day had made twice the height growth in Florida as in Wisconsin. Many of those in Florida set terminal buds early in the first season, and then made a second flush of growth. This also was the pattern of growth during the second season, but because of less variation between plants in the time of the second flush, a more abrupt change in growth rate appears, with formation of terminal buds early in the season and their subsequent expansion. The heights of red pine under natural day in Florida averaged about the same as those in Wisconsin but were of poor vigor and color.

White pine showed somewhat similar behavior. Under long day it made excellent growth in Florida during both seasons and averaged twice the height of plants under long day in Wisconsin. The Florida plants did not become dormant the first season until the end of the long-day treatment; the second season, buds were formed in the early part of the growing period and then a second flush of growth was formed. This pattern of intermittent growth also occurred the second season in plants under long day in Wisconsin. Under natural day, the average height of white pine plants was about the same in Florida as in Wisconsin.

White spruce plants under long day in Florida were about the same height as the plants under long day in Wisconsin but nearly twice the height of the white spruce growing under natural Wisconsin photoperiods. Growth of white spruce under long day in Wisconsin continued without interruption by terminal bud formation during the growing season; the second season an unusually early fall frost resulted in some minor damage to the still tender tips. Plants under long day in Florida did not become dormant until

after illumination was discontinued in late October, 4 weeks before the average date of the first killing frost. White spruce under natural day in Florida was severely dwarfed by the short natural photoperiod; vigor was low, with mortality continuing throughout the two seasons.

For black spruce, results were about the same as for white spruce except that height growth was considerably greater for this faster growing species. Plants under 20-hour day were about the same height as those under long day in Wisconsin. At both locations, the long-day treatment gave uninterrupted growth throughout the growing season, with slight damage in Wisconsin from an early frost at the end of the second season. Natural day in Florida gave poor survival, low vigor, and stunted plants.

Initiation of growth at the beginning of the second season in Florida was a function of temperature rather than photoperiod, for plants under both treatments began growth at the same time. The prompt initiation of growth in the spring indicates that the chilling requirement, the need for cold to bring about internal changes in plants in a state of winter dormancy, has been met by the natural and rather limited low temperatures of the Florida winter for all species but red pine under natural day. Red pine under natural day flushed irregularly and later in the season than red pine under long day.

At both locations, white and black spruce under long day bore more and longer lateral branches than corresponding plants under natural day. Thus long-day treatments produced plants of good form, both height of the main stem and growth of lateral shoots being increased.

Measurements of spruce in the second planting, taken toward the end of the second season, indicate that improved drainage conditions will give plants much larger than those shown in the graphs.

Plants grown under long day in Florida were well balanced, with good development of both tops and roots at the end of the second growing season (fig. 9). Extension of the roots into the lower layers of the soil was apparently hindered by the excessive soil water in the original planting; normal roots developed in the second planting, made in the better-drained beds. Nevertheless, the top-root ratios, a comparison of top weights with root weights, were low, with average ratios ranging from 1.27 for white pine to 2.42 for black spruce. A ratio of 3 is considered very good for northern-grown transplant stock.

Comparisons of plants under long day in Florida at the end of the second season with the minimum standards for 2-1 and 2-2 transplant outplanting stock of Lake States species show that the Florida stock equals or exceeds these standards of height, diameter, and top-root ratio.

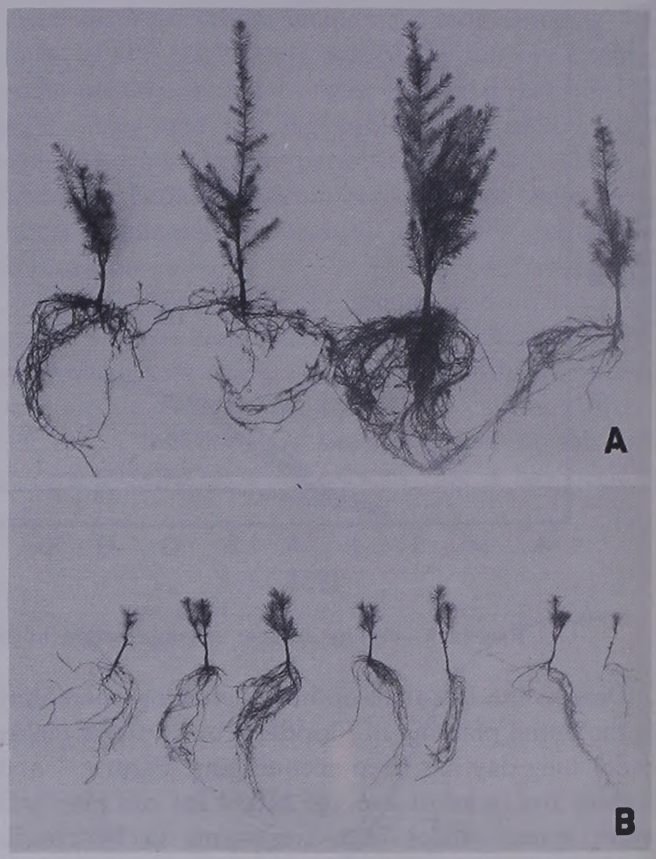

FIGURE 9.—Two-year-old white spruce seedlings grown in Florida: *A*, under long day; *B*, under natural day.

A small number of 2-0 seedlings raised under extended day in Florida were outplanted in Wisconsin in the spring of 1960. One group of seedlings was lifted in February while still dormant and placed in cold storage until planted in May; the other group was lifted in early May, while actively growing. Survival at the end of the first season of the seedlings lifted in February equaled that of 2-2 transplants obtained from regular production in the Hugo Sauer Nursery. The Florida plants lifted in May did not survive as well. Lifting, storage, and shipping of Florida-raised plants appear to present no important problems.

This work is continuing in Florida to determine optimum nursery management for these four northern species. The biological feasibility of growing white and red pine and white and black spruce in a warm climate with artificially extended photoperiod is firmly established. Production of plants from seed for experimental purposes, such as in tree breeding programs, is a possible use of this technique; ultimately it may open the way to cheaper and more rapid production of high-quality outplanting stock for reforestation.

Extension of the photoperiod in nurseries in the northern portion of the Lake States does not appear to be practical for increasing the growth of white and red pines. However, white and black spruce responded with greatly increased height growth during the second season. This generally greater size of the 2-0 spruce should cut the percentage of cull, due to small size, in seedlings being transplanted in the nursery.

Dormant Hardwood Cuttings Induced to Grow

Gibberellic acid can promote growth on dormant hardwood cuttings, according to a study recently made at the Northern Institute of Forest Genetics. This study consisted of two experiments. In the first, dormant cuttings of red maple (*Acer rubrum*), quaking aspen (*Populus tremuloides*), and Bebb willow (*Salix bebbiana*) were collected in April 1957 and treated with the following growth regulators in lanolin at three concentrations (¼, ½, and 1 percent by weight): gibberellic acid, 2, 3, 5-triiodobenzoic acid (TIBA), and 3-indoleacetic acid (IAA). The cuttings (including some untreated checks) were kept in tap water in the greenhouse where they were observed regularly. The second experiment included cuttings obtained in January 1958 from juvenile stump sprouts and root suckers and from mature trees of red maple, quaking aspen, paper birch (*Betula papyrifera*), bigtooth aspen (*Populus grandidentata*), and from mature trees only of northern red oak (*Quercus rubra*), boxelder (*Acer negundo*), butternut (*Juglans cinerea*), and pin cherry (*Prunus pensylvanica*) treated with gibberellic acid at a concentration of 1 percent in lanolin.

There were species differences, of course, but the results of both experiments were similar: in the gibberellin-treated cuttings not only was dormancy broken earlier but also a considerably higher percentage of the topmost (apical) buds broke dormancy as compared to the controls. Northern red oak (no effect) and butternut (slight effect) were exceptions. Apparently the early development of these buds indirectly suppressed the growth of the underlying laterals by exerting apical dominance over them. Increasing lateral bud inhibition with increasing concentration of gibberellic acid indicated an additional, unexplained direct effect. Juvenile cuttings broke dormancy earlier than similarly treated mature cuttings, although the latter showed a comparatively greater response to treatment.

The triiodobenzoic acid treatments, on the other hand, resulted in lateral bud growth comparable to that of the apical buds. It is thought that this is a consequence of TIBA's interference with the movement of the natural auxin through the stem and hence the restraint of apical dominance. The indoleacetic acid treatments caused a temporary delay in bud break by exerting a simulated apical dominance over all buds on the cuttings. For some unknown reason, however, IAA seemed ineffective on quaking aspen.

These findings may have potential application in forest research where it is often desirable to promote the growth of dormant plants and cuttings or to prolong the normal growth period.

Elongation Growth and Auxin Synthesis Affect Cell Size

When there is active elongation growth and high synthesis of auxin, large-diameter springwood cells are formed; when such growth ceases and auxin content diminishes, narrow-diameter summerwood cells are produced. Those are the conclusions derived from a study recently completed by the Station.

This study was made on red pine transplants potted in the spring, maintained in the nursery until October, and then held in an outdoor coldframe until mid-December when they were brought into the greenhouse. There they were stimulated into active growth by exposure to 18-hour daylength, and all lateral buds were pinched off as they developed. The transplants were used in two experiments in which artificial treatments were tested for (1) maintaining springwood formation and (2) producing false rings. Except for some control plants, short-day (8 hours of light) pretreatments for 3 weeks were used to stop height growth in the first experiment. Then the fol-

lowing treatments were applied: short-day, long-day, and short-day plus three concentrations of 3-indoleacetic acid, lanolin alone, and gibberellic acid at 1-percent concentration on decapitated tips. In the second experiment both short-day and long-day pretreatments were followed by treatments such as long day throughout the summer, debudding plus long day, and debudding plus short day. Plants from each treatment were collected at 4- to 7-day intervals, segments were taken at various positions on the stem, and these were sectioned and mounted on microscope slides.

The results of this study indicate a regulatory effect of the bud on cellular development. They also suggest that the regulation of cell diameter may be hormonal in nature, presumably an auxin originating in the bud or growing shoot.

Seedlings grown under long-day conditions continued to produce springwood-like cells for an extended period of time. Summerwood-like cells could be induced to form either by short-day treatment or decapitation. When seedlings were transferred from short-day to long-day conditions, springwood-like cell production was resumed, but only in seedlings with an intact bud. Limited production of springwood-like cells was induced in decapitated, short-day plants by applications of 3-indoleacetic acid.

It seems evident that any factor that causes terminal elongation growth to begin prematurely or to cease will bring about a respective increase or decrease in cell diameter. The extent to which a change in terminal activity will register an accompanying change in xylem tracheid development depends upon the intensity of the apical stimulus. Thus, a false ring originating from a "second flush" of growth may be evident only in the uppermost parts of the stem. The increase in summerwood cell wall thickness is due to a physiological process separate from that causing the decrease in cell diameter, although the two phenomena occur more or less simultaneously in normal summerwood development.

Knowledge of Auxin Gradient Effects on Cell Size Reviewed

To bring into focus current knowledge on how auxin gradients may regulate cell size, a review has been prepared covering both the results of Station research and published reports from other sources. This was done with full realization that a number of substances and factors, both external and internal, form a chain of events leading to growth, and that auxin is a single, but important, link in this chain.

Cambial activity and xylem development are more or less continuous processes in nature, but it is convenient to discuss the progression and consequences of radial growth in three separate categories: (1) the initiation of cambial activity, (2) the formation of the annual ring, and (3) the regulation of stem form. Presently available knowledge, particularly for the pines, gives us the picture that follows.

The cambia of Temperate Zone trees are dormant in the winter, and no auxin activity can be found then. Following warm spring weather the buds begin to swell and auxin activity can be detected in the bud tissues. Shortly thereafter the cambia become active beneath each developing bud. As the buds continue to expand and the new leaves unfold, the wave of cambial activity progresses down the main stem and branches and eventually envelops the entire bole.

Changes in cell size account for the formation of annual rings, and recent evidence indicates that the primary role of auxin in differentiating xylem appears to be as a determinant of cell size. Large-diameter springwood-type cells are produced when terminal growth is active and auxin synthesis high, and the transition to narrow-diameter summerwood-type cells occurs when terminal activity and auxin synthesis decline. The same general process can account also for the formation of false rings.

Stem form depends on the distribution of radial growth along the main stem axis of the tree. The regulation by auxin of this distribution may be visualized in this way: (a) The auxin source lies within portions of the growing crown, so the supply is not available equally to all parts of the stem below. The auxin gradients within a tree must be considered, therefore, as concurrent functions of time and space. (b) The time factor may be considered as the normal seasonal transition from springwood to summerwood across the annual ring. (c) The distance factor is the variation in cell size within the annual ring down the stem and away from the auxin supply of the crown. Thus the annual rings of the upper stem are composed almost entirely of springwood-type cells, further down the stem there is a gradual divergence into reconizable springwood and summerwood, and in the lower stem positions true, narrow-diameter summerwood cells are produced.

Occurrence and Effects of Lammas Growth and Prolepsis on Jack Pine [2]

The annual height growth in jack pine normally occurs in a single spurt, but second flushes of growth are not uncommon. They are of two general types: (1) Lammas growth is characterized by one or more periods of secondary elongation following the first elongation of the terminal shoot earlier in the season (fig. 10). Typically the normal winter bud is formed, but later opens and additional height growth takes place. (2) Prolepsis refers to a similar development of lateral buds at the base of the terminal bud (fig. 11). Lammas growth and prolepsis can occur singly on a given tree or in combination. They can be readily observed on young jack pine trees in late autumn when all growth in height has been completed and the trees are in an apparent winter condition. They are characterized by densely spaced, short secondary needles, and by their greener color and less matured appearance than that of normal shoots.

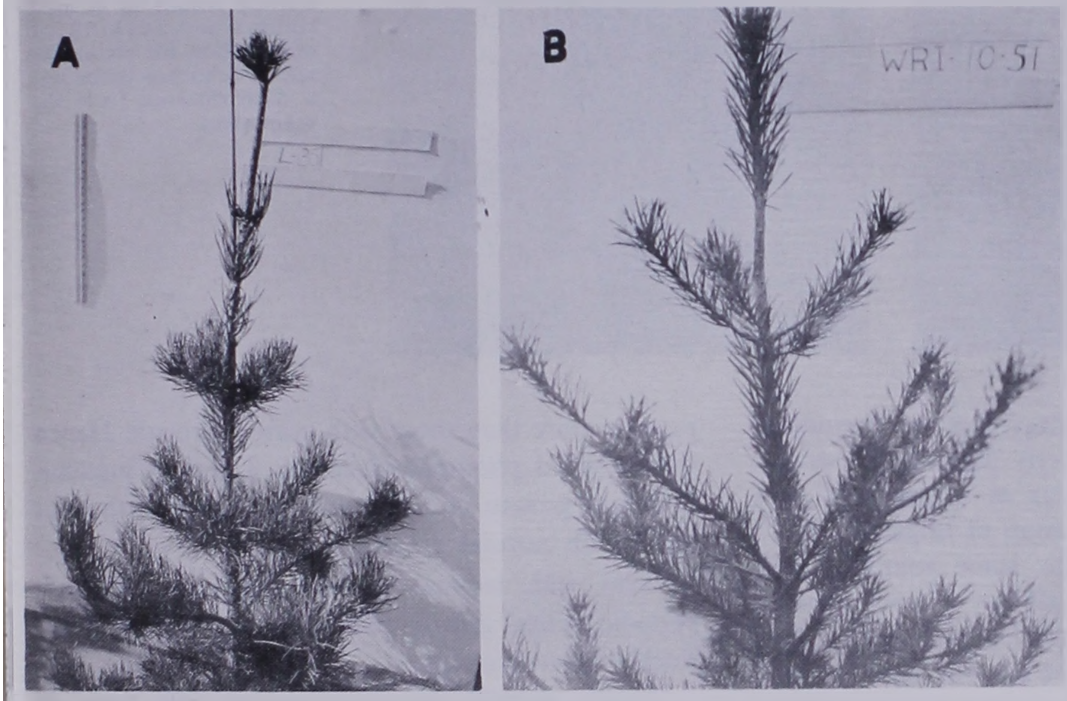

FIGURE 10. — Lammas growth; (*A*) At the end of the current season. (*B*) After 1 year a short internode and clustered branching have resulted.

Lammas growth and prolepsis may result in undesirable deviations from normal shoot development and tree form. Observations of these growth phenomena by foresters working in jack pine areas have led to much speculation as to their significance, but our knowledge about the factors controlling their occurrence or about their effects on growth and form is negligible. Hence, a study was undertaken to determine the characteristics of lammas growth and prolepsis in jack pine, the variation in frequency of occurrence of these phenomena over the range of the species in the Lake States, their effects on height and diameter growth and tree form, and possible factors influencing their occurrence in certain areas and on individual trees.

The major part of the study was made in the 30-source regional jack pine seed source plantations established in 1954 by the Lake States Forest Experiment Station and the University of Minnesota. Late season growth flushes were observed: (1) for 3 successive years in the 30 sources on all the trees in three of the four blocks of the Cloquet, Minn., planting; (2) for 2 years in 10 sources on three other plantations in Minnesota and two in Wisconsin; and (3) for 2 years in four young natural jack pine stands in Minnesota.

The effect of photoperiod length as a probable influence was studied in a set of plots established for that purpose at Grand Rapids, Minn. Periodic height-growth data were collected from 300 trees in the Cloquet planting and from the Grand Rapids plots.

Analysis disclosed the following information:

The frequency of occurrence of lammas growth,

[2] Study conducted in cooperation with the School of Forestry, University of Minnesota.

prolepsis, and their combinations varied significantly (.01 level) between seed sources in all cases in all the plantations studied.

The frequency of occurrence varied significantly between plantations and from year to year.

Regression analyses of the relationship between the frequency of occurrence and latitude, degree days over 50° F., and average July temperature of the seed origins show that the frequency changes predictably with changes in these factors. Frequency increases with more southerly latitude of origin; with increase in degree days of origin; and with higher average July temperature of origin.

Multiple range tests show some sources to be significantly different from all but a few others in the incidence of these abnormal growth habits. This may indicate that not only the general region of seed collection is important, but also that progenies from seed collected in particular stands may show a higher frequency of these undesirable growth habits; therefore seed collections from such stands should be avoided.

Photoperiod artificially extended to simulate the daylength regime prevailing at 58° N. latitude caused trees growing at 48° N. to double the frequency of lammas and proleptic shoot production—from about 30 percent in the unlighted plot to more than 60 percent in the illuminated plot.

Trees with lammas growth had a significantly longer growing period than those with normal growth, and all trees grew for a longer period in the lighted than in the control plots.

In the lighted plot, trees with lammas growth grew 10 percent more than those with normal growth. In the control plot, trees with lammas growth grew 6 percent more than those with normal growth. Hence the extended photoperiod caused a greater increase in height growth in trees with lammas growth than those with normal growth.

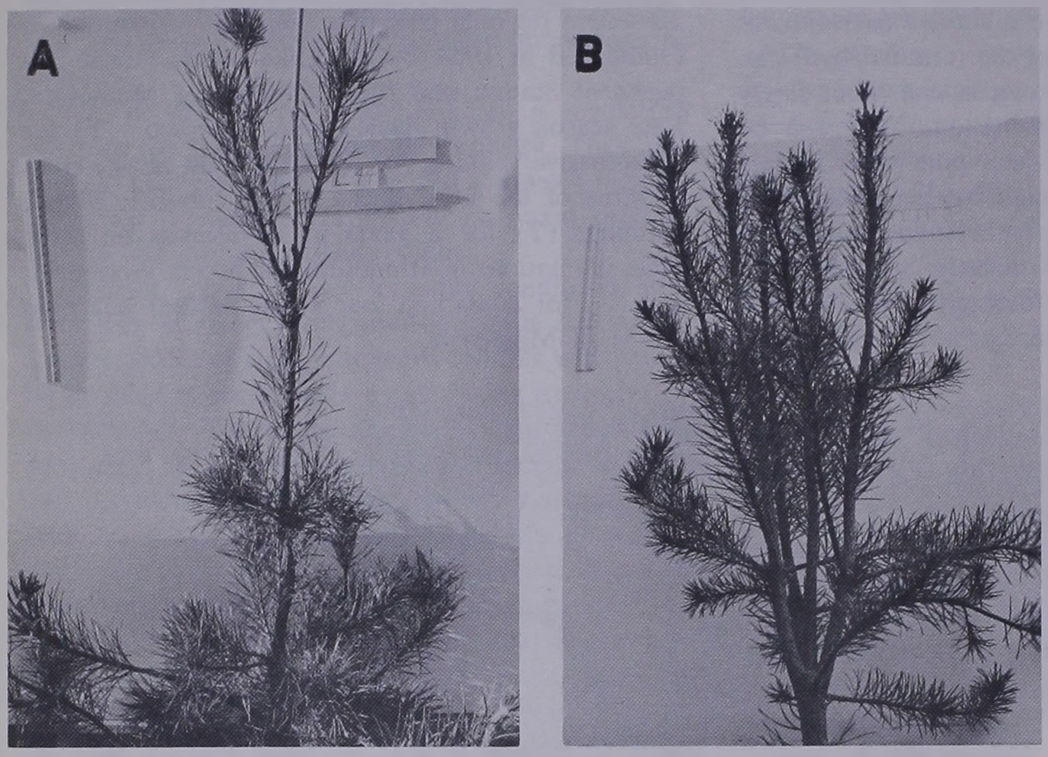

FIGURE 11.—Prolepsis: (*A*) At the end of the current season. (*B*) As observed 1 year later, prolepsis frequently results in at least temporary forking or competition for secondary lateral branches borne but a short distance from the main stem.

Trees with lammas growth showed a different periodic height growth pattern as determined from weekly measurements.

Weekly growth measurements on 300 trees at Cloquet, half of which had supported lammas growth the previous season, showed that trees with lammas growth grew slightly less the following season than those with normal growth, though the difference was not significant.

Lammas growth and prolepsis did not result in detectable increases in diameter growth nor in false rings in the trees observed in this study.

Apparent frost rings were frequently noted in the current year's shoot in trees with lammas growth, even though external evidence of frost injury appeared on only 0.1 percent of lammas and proleptic shoots under natural growing conditions.

The occurrence of these phenomena is not restricted to planted trees but occurs in natural stands as well. Although their occurrence is modified by environmental factors, it is under genetic control; and seed collection from trees with lammas growth and prolepsis or in stands with a high frequency of occurrence of these growth types should be avoided.

WATERSHED MANAGEMENT

SIDNEY WEITZMAN, *Division Chief*

Watershed research at the Lake States Station has gone underground. In the past, Forest Service watershed research has dealt largely with surface phenomena—surface runoff, its volume, timing, and quality, and surface erosion. However, the hydrologic problems in the Lake States and their solutions call for probing into the water behavior below the surface of the ground.

The reason for this may be found in an understanding of the geology and topography of the area. All of the Lake States region, with the exception of the Driftless Area, has been subjected to the action of recent glaciers. As a result, the topography is relatively gentle. Only in the Driftless Area are rapid surface runoff and its concomitant erosion a common problem.

The region is covered with a mantle of glacial drift varying in thickness from a few feet to many hundreds of feet. This gives rise to typical glacial features: gravelly moraines, outwash plains, old lake beds, thousands of lakes, and vast areas of bogs and swamps. All of these features provide excellent opportunities for ground-water storage and movement. The first part of this report on our watershed research deals with ground-water hydrology.

Not all our problems are underground, however. Studies of surface phenomena are also underway. These are designed to answer local watershed problems caused by surface use and disturbance. For example, one such study deals with sediment behavior in streams as a result of streambank erosion. Other studies deal with the effect of cover manipulation on water use and supply. In the Driftless Area with its rolling-to-rough topography and highly erosive soils, erosion and sedimentation problems relating to wind-blown loessal soils are under study. These special studies are outlined in the second part of the report.

UNDERGROUND WATER STUDIES

In Bogs and Swamps

A dominant hydrologic feature of the northern forest zone in the Lake States is the vast 10-million-acre forested bog and swamp area. Characterized by a deep accumulation of organic soils, high water tables, and impeded drainage, these bogs and swamps are suppliers of water—a headwaters area. Conflicts for the use of the land and the water resource are

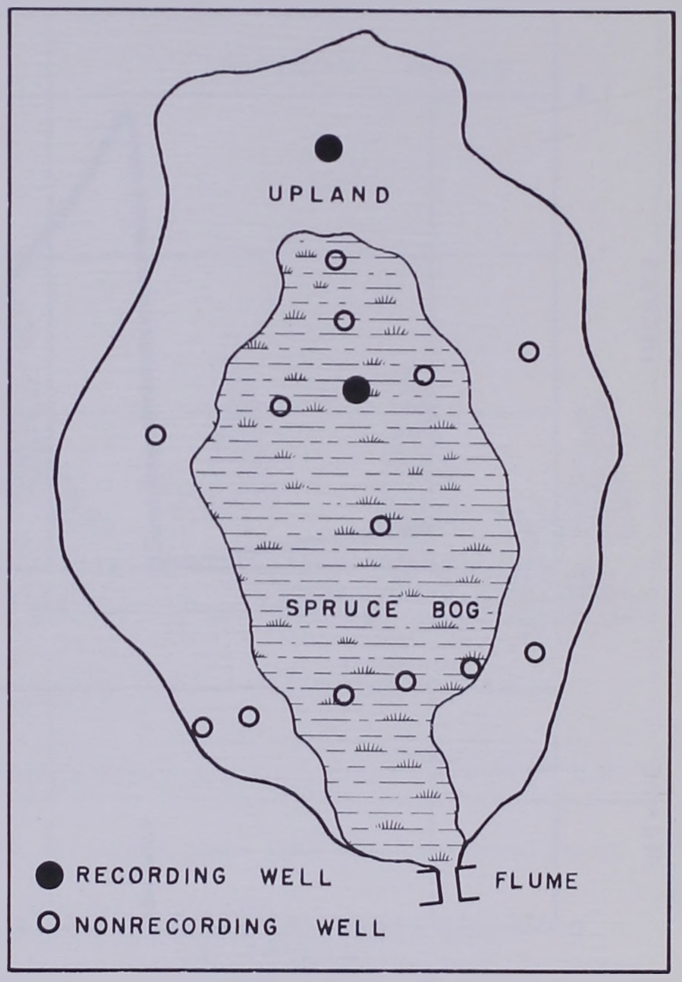

FIGURE 12.—Installation of wells and flume in a small watershed draining into a spruce bog, northern Minnesota.

developing. Yet no one knows the value of these areas as a source of ground-water recharge or as a stabilizing influence on streamflow. Basic to an understanding of the local hydrology is a knowledge of bog hydrology.

To this end, several swamp watersheds were selected and instrumented for study north of Grand Rapids, Minn. A weather station and a runoff measuring device were installed to measure how much water falls and how much runs off the surface. In addition, a network of ground-water wells was established to check water-level fluctuations (fig. 12). Each swamp has a recording well, supplemented by three transects of nonrecording wells which will be observed periodically. These will enable us to plot water-table contours at periodic intervals and trace behavior of water in the bog.

Some interesting data are coming in. Figure 13, for example, shows the rapid recharge of water tables in a forested peat swamp following precipitation. Such sharp fluctuations have normally been considered characteristic of steep mountain watersheds rather than of bogs and swamps.

Information on water-table levels will be correlated with precipitation and runoff to determine the normal behavior of swamp watersheds. Such studies should provide answers on the role of swampland in water behavior. Do these swamplands effectively regulate streamflow? How much water do they store? Do they contribute to ground-water recharge? And how do forest management practices affect the hydrology of these areas?

Some exploratory work on swamp drainage was started 35 years ago and abandoned. The tentative conclusions reached then are still subject to strong controversy. The new techniques and better scientific controls now available should give us more definitive answers. Though long delayed, a start has finally been made in this promising but neglected field of research.

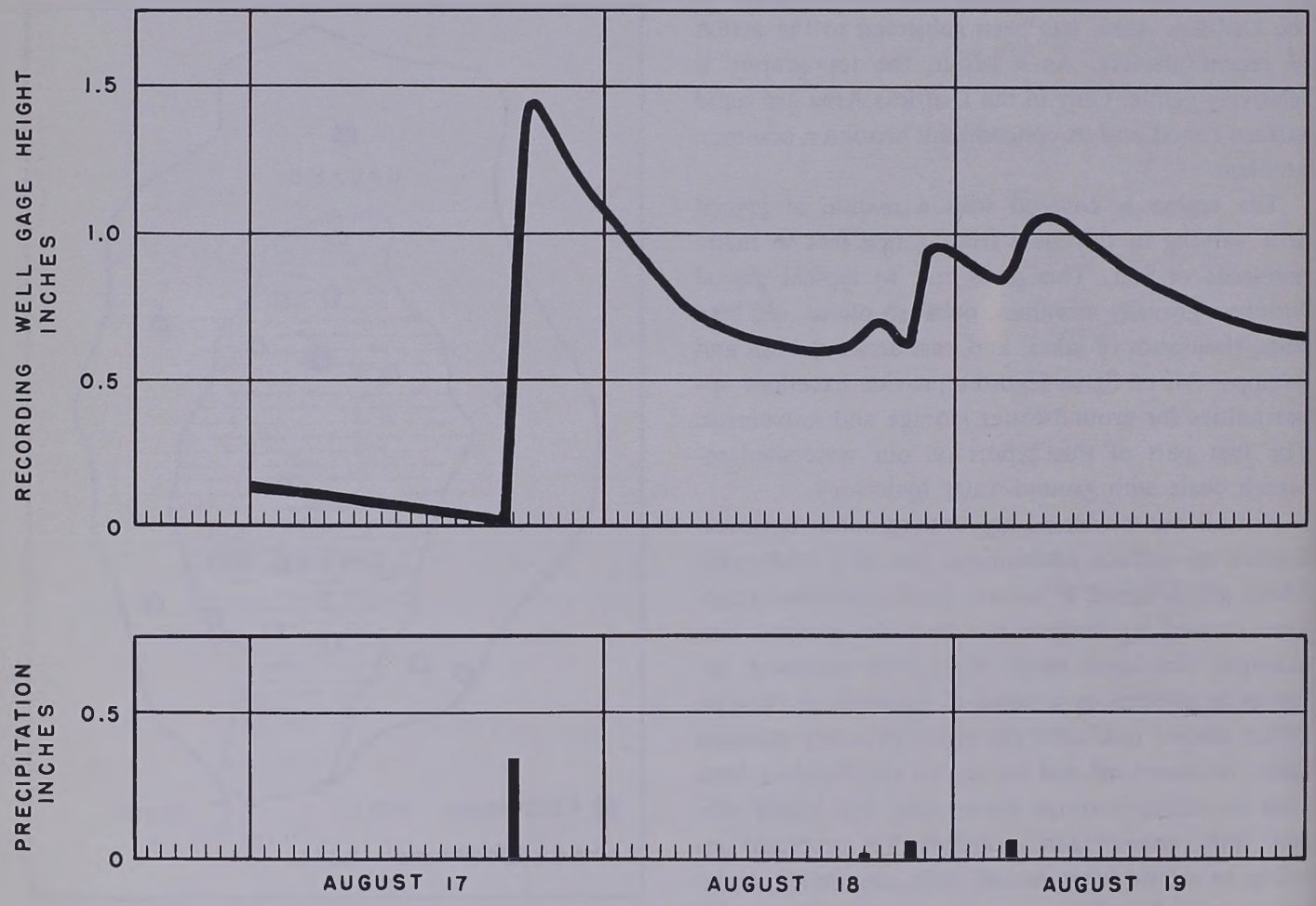

FIGURE 13.—Comparison of ground-water fluctuations with precipitation in a forested peat swamp.

In Ground Water Movement

Another land feature that directs our watershed studies below the ground is the forested sandy moraine with its surrounding outwash plain. Surface runoff is negligible from these areas. Water percolates to the ground-water reservoirs where it moves horizontally to supply lakes, streams, and bogs.

The typical features are well represented on various parts of the Udell Hills Experimental Area on the Manistee National Forest in Michigan. This is a morainal upland (with deep water tables) surrounded by a level outwash plain (with shallow water tables).

To determine the nature of the ground-water movement through these mineral soils, a series of test wells was installed. Figure 14 indicates the location of these wells in relation to the characteristic topographic features and ground-water levels. Our records indicate that the depth of water tables below the surface is related to topographic position and the presence of clay layers. The timing and amount of recharge are also affected by these factors.

Typical water-table recharge patterns for four types of wells are shown in figure 15. Curve A traces the water levels in a shallow well located on the outwash sand plain. The water table is in the root zone

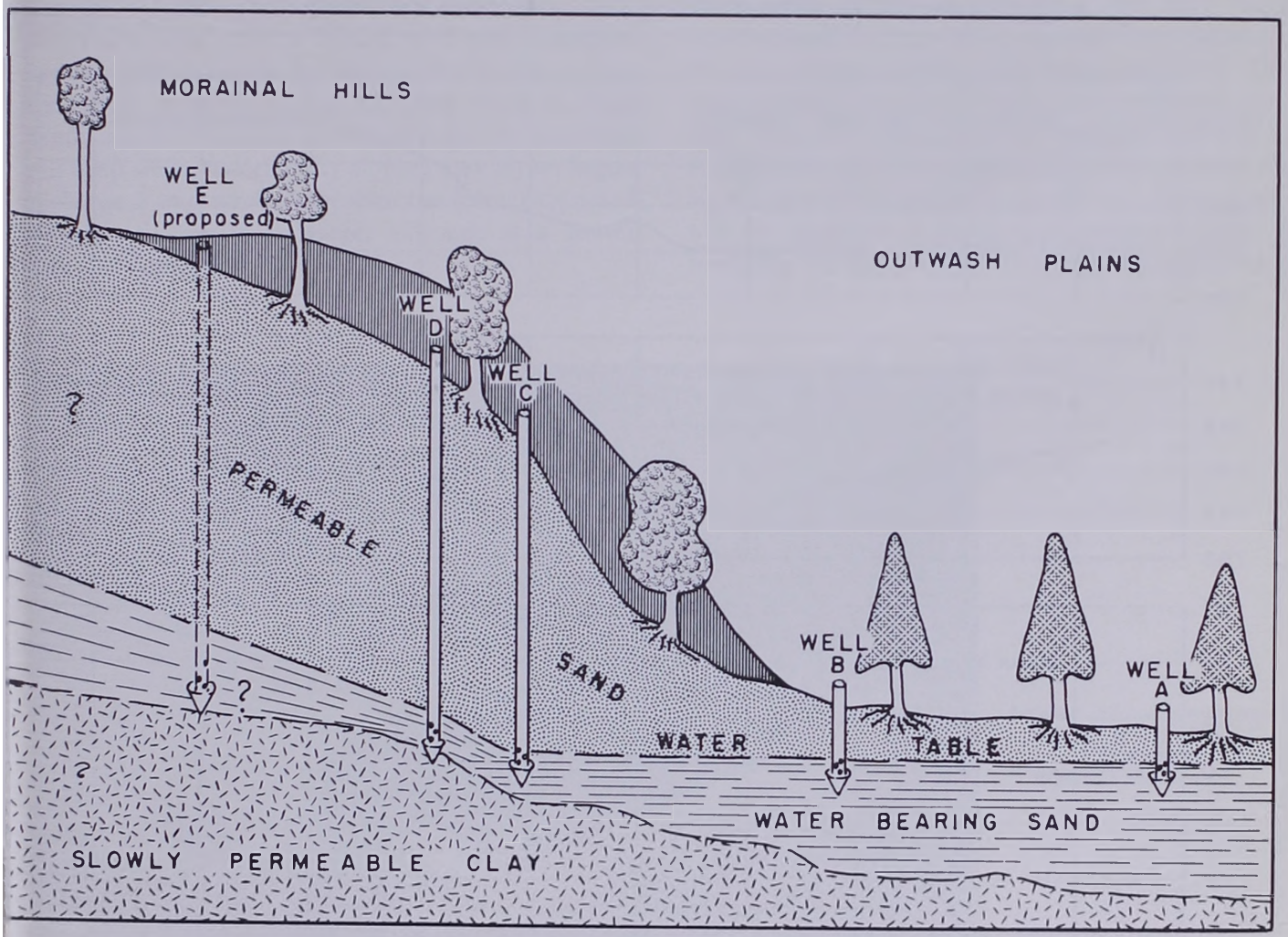

FIGURE 14.—Diagrammatic position of wells on morainal hills and outwash plains, Udell Hills Experimental Forest.
Well A: Shallow rell in outwash plain. Roots reach to water table.
Well B: Moderately shallow well in outwash plain. Water table below root zone.
Well C: Deep well on lower morainal slope. Water table nearly level with adjacent outwash plain.
Well D: Deep well in floor of upland valley. Sloping clay layers under 1-2 ft. of waterbearing sand; clay surface and water table slope approximately 5-6 percent.
Well E: Proposed installation two-thirds of distance up morainal slope from outwash.

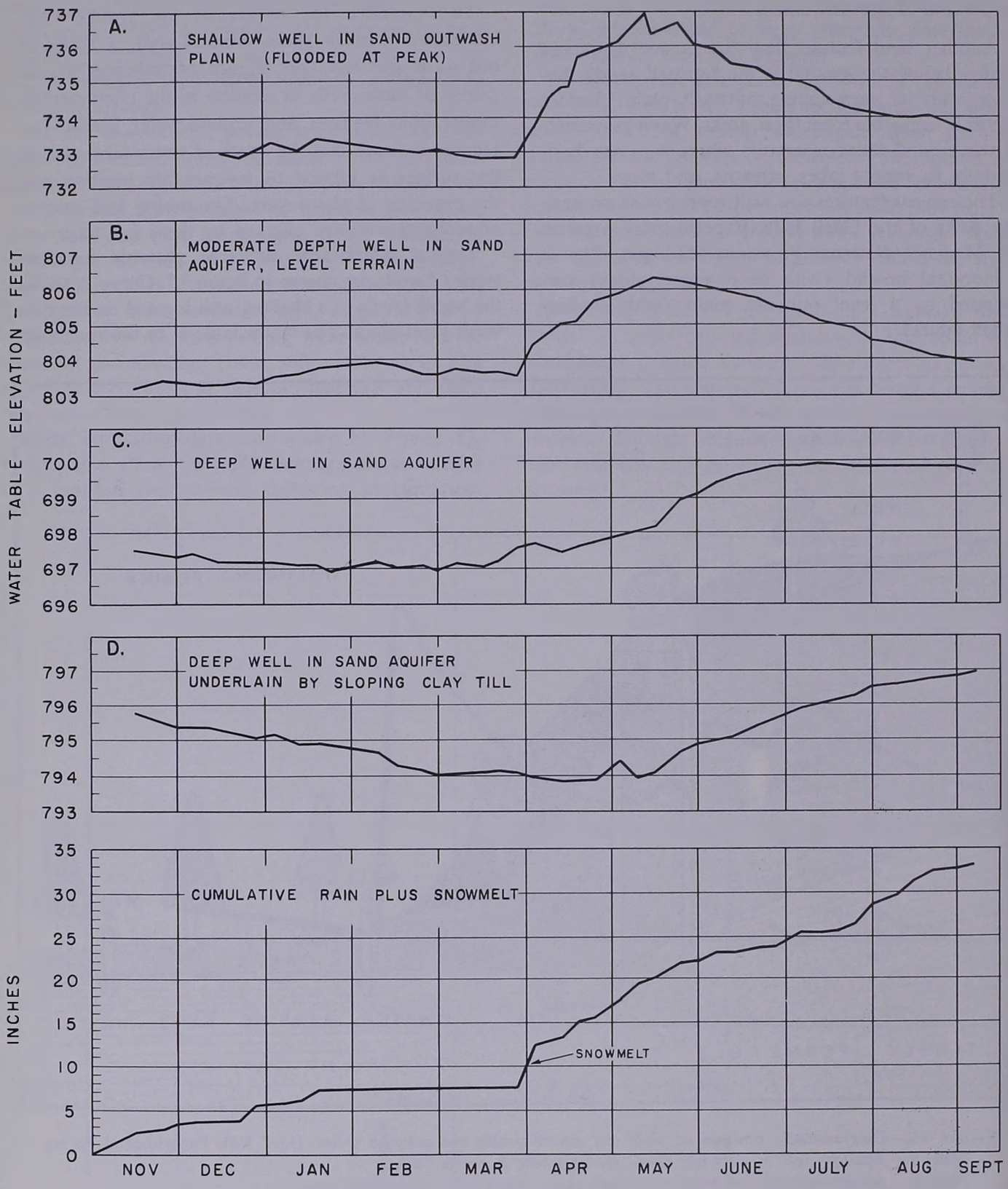

FIGURE 15.—Recharge curves for wells shown in figure 14, Udell Hills Experimental Forest.

throughout the year. The curve illustrates both (1) the rapid response to recharging precipitation and (2) the decline of the water table during the summer period when plains transpire water from the underlying reservoir. The well for curve B is also in the outwash plains, but the water table is just below the root zone. The data show a somewhat slower rise in the water-table level after rainfall than occurs in well A. The curve is smoother since drainage is controlled by the permeability of the aquifer materials and not by the demand of plants.

Wells C and D are in the deeper moraine. Their recharge patterns illustrate the lag of 6 to 8 weeks between the availability of moisture (i.e., snowmelt March 27 - April 4) and the rise in the water table. Curve C is from a 70-foot well with a deep sand aquifer. Curve D is from a 55-foot well with a shallow sand aquifer underlain by sloping clay layers. During the 1960 recharge period all deep wells in deep sandy aquifers reached maximum stages by mid-July. All deep wells underlain by sloping clay layers began recharge 3 to 6 weeks later than the former type and were continuing to recharge, although at a slower rate, on September 5.

Future studies will determine the source of the water for each type of well and the effect of changes in forest cover on the amount of water yield in these underground "watersheds."

In Springflow Behavior

Another underground study deals with the flow of springs in the nonglaciated or Driftless Area represented by the Coulee Experimental Forest in southwest Wisconsin. Spring flow is a common feature of the area and is related to local geologic formations. Some springs emerge in stream channels. Others come out of sidehills or ridges.

The studies are keyed to determine the effect of cover manipulation on springflow. We have heard reports about springs drying up after trees were cut, but no reliable evidence has been produced. This area provides the clinical material to solve the question. Thus, the effect of cover manipulation will be studied not only on surface runoff but also on the accretion and depletion of springflow. Observations will be made on a controlled watershed basis. If removing the cover results in increased surface run-

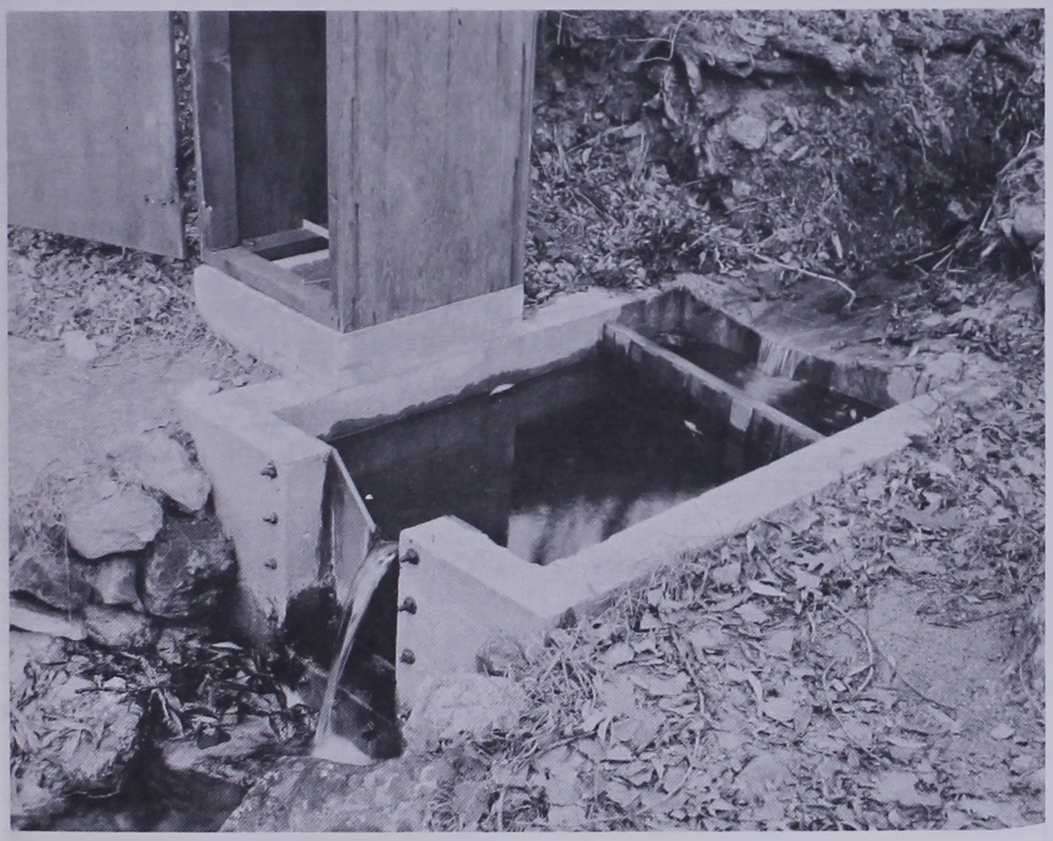

FIGURE 16.—Flow from a sidehill spring on the Coulee Experimental Forest under calibration.

FIGURE 17. — The relative contribution of eroding streambanks to sediment load will be tested.

off, then is this reflected in decreased streamflow? If more water gets into the ground as a result of reforestation, do we find a substantial increase in springflow?

Some springs are being calibrated now to determine their seasonal behavior prior to treatment (fig. 16).

SURFACE WATER STUDIES

In addition to the underground studies discussed, other studies are underway. These include both long-range projects and short-term studies. Some recent studies are briefly mentioned.

Sedimentation in Streams Can Be Controlled

There is renewed emphasis on stream sedimentation and water-quality research. This interest has resulted from an increasing awareness of the relationships between trout populations and water quality as affected by erosion. Erosion in forested and semi-forested watersheds is most apparent along stream channels where eroding banks contribute sediment directly to the stream (fig. 17). The rehabilitation of trout streams through stabilization of these eroding banks has been the first approach of the Michigan Conservation Department. Stabilization treatments consist of rock-riprapping waterlines, seeding and fertilizing upper banks, fencing, and tree planting. As indicated in our Station Paper 84 (see List of Publications at end of report), these practices are highly effective in stabilizing waterlines and reducing bank erosion.

Current research is aimed at (1) further evaluating treatment as it affects actual sediment loads in the stream, and (2) relating sediment yields, chemical properties, and stream temperatures to land use, soil type, rainfall, stream discharge, length of gradient of stream channels, and length of eroding banks along stream tested.

Results should permit an identification of problem erosion areas and thus permit land managers to concentrate or modify treatment according to the individual situation.

Soil Moisture Varies Greatly by Aspect and Cover

A study of soil moisture in the Driftless Area in forest and grassland shows a marked variation by aspect and cover for comparable surface layers. In

the top 2-foot layer, soil moisture was found to be about twice as high on north-facing as on south-facing slopes. It also tended to decrease as one went up the slope. Moisture content was higher under northern hardwoods than under planted white pine in similar slope position and aspect. On a south-facing slope, tree volume growth in a planted Scotch pine stand was about 3.5 times as high as in a scrubby oak stand, indicating the potential in converting some of the poorer oak stands to pines.

Grazing Drastically Reduces Infiltration Rate of Forest Soil

Infiltration tests made by the use of steel cylinders showed a marked reduction of rate of water intake in forests that were subjected to livestock use. The trials, run in the Driftless Area of southwestern Wisconsin, are summarized below:

Cover	*Infiltration* (Inches per hour)
Ungrazed oak woods	7.46
Grazed oak woods	.05
Ungrazed Scotch pine plantation	11.02
Grazed Scotch pine plantation	1.23

Obviously, keeping livestock out of the woods improves the hydrologic role of the forests in keeping water intake at a maximum.

NEW INSTRUMENTS AND TECHNIQUES

Because of the specific research requirements of the Lake States area, the relative newness of some fields of watershed research, and the swift advances in other sciences, some of which are adaptable to our work, new instruments and techniques must be devised and tested. Some of these are commented on briefly below.

Wells in peat soils.—Wells in peat soils will frost-heave. Past experience indicates that they move several inches a year. To solve this problem the well pipe is anchored to the mineral soil beneath the swamp. The "anchors" are steel plates, 6 inches in diameter, which are cut and twisted to form an auger-type blade. These are welded to a pipe coupling which is attached to the well pipe. The entire unit is turned through the peat and into mineral soil. This type of auger was originally developed by the Halvorson Christmas Tree Company.

Analog-to-digital recorder. — Two Fisher-Porter analog-to-digital recorders are installed and in operation on the Coulee Experimental Forest. We will test their response under two different types of streamflow. One is installed on a dry gulch, with intermittent flows and sharp peaks coming from steep watersheds. The other is recording spring flow, which rises and falls slowly. If these recorders operate satisfactorily, they will practically eliminate office computations and facilitate analysis.

Test of neutron moisture meter. — The nuclear soil-moisture apparatus has been operated for a year on a trial basis. The object was to find out how well it could be used in our research program—specifically, to determine additions to ground water and to measure changes in soil moisture. The instrument shows much promise even though two possible sources of error were observed. These are (1) possible inaccuracy of the instrument's rating curves, and (2) unreliability of soil moisture estimates in the top 8 inches of soil. Methods for making corrections and adjustments are now being worked out.

Automatic trigger device. — Our water-level recorders are used where flows occur only after heavy rains or on frozen ground. On the Coulee Experimental Forest, flows may occur from three to five storms in an average year. This means that for weeks or months at a time the instrument records nothing. But where 8-day, clock-driven recorders are used, all gages have to be visited at weekly intervals regardless. We have developed an automatic triggering device which permits the water-level recorders to operate only when water begins to flow past the measuring station. Clocks need to be rewound and charts changed only after periods of flow, thus eliminating the weekly visits to gaging stations.

PROGRESS TOWARD A COMPREHENSIVE PROGRAM

The research effort of the Division has progressed from the orientation short-range study stage to the beginning of a comprehensive program. Experimental areas for the three field units that will conduct watershed research have been selected. Two of the field units now have a small soil and water laboratory and all three have two full-time scientists each. The future effort will be devoted to developing the research program on the experimental forests—each one representative of a major problem area in the territory.

FOREST RECREATION

J. T. MORGAN, *Division Chief*

For the last several years it has been apparent that the increasing summer use of forest lands for camping and other outdoor recreation activities is presenting serious problems to forest land managers. Without reliable information on the number and kinds of forest visitors, the activities they pursue, and the types of environment or facilities they are looking for, it is difficult for administrators to plan. Furthermore, before plans for recreational development can be made, policies must be determined on how much land and how much capital should be invested to provide for recreational needs. Research results are required to guide policy determinations.

Beginning in 1960, the Station initiated a small program in forest recreation research. One of the most critical areas in the Lake States, from the standpoint of pressure for different kinds of uses, is the Boundary Waters Canoe Area—a million acres of lakes and forests on the Superior National Forest.

Recreation visits to this headline-collecting country are climbing fast. How fast? What do "visits" mean in terms of length of stay and uses of the forest environment? The Superior National Forest's hard-earned estimates show the number of visits doubling from 1950 to 1959, when the total topped 100,000. No one is really satisfied with the accuracy of these estimates, however, despite efforts to improve them. Two objectives of the Station's first study of recreational use are to provide reliable figures on present use as a base from which to measure trends, and to devise a dependable and economical method for measuring future use here and in other types of forest areas.

Satisfying recreation demands is not easy. "Mass solitude" is a seeming paradox. Pinning down the problems and making a start on their solution calls for more understanding of the ideas of the people who come to the Canoe Country and a better comprehension of the geography of their recreation after they arrive. How much of each type of recreation—canoeing, camping, boating, and even water-skiing—is there? How are these activities distributed over the area? What are the appeals of the area in the minds of the users? How much of the forest do they consider "wild"? What factors detract from their satisfaction? Is overcrowding serious and, if so, in what ways?

In 1960 a start was made on these and related questions. Data were collected by two methods, the main method being a roadside survey (fig. 18). The Boundary Waters Canoe Area was formerly called "roadless," and around it the highway net unravels into dead-end roads. Automatic traffic counters on these dead-end roads measured total traffic flow, and short interviews of a sample of motorists leaving the area (over 3,000 of them) gave a basis for estimating the composition of this flow—what proportion was recreational and how this fraction was subdivided by types of activity, areas used, and length of stay, for example.

The second level of data collection was based on a much longer questionnaire used in more leisurely settings—people in campgrounds, guests at resorts, and canoeists returning to their cars, over 200 groups in all. Some private cabin owners may also be contacted later. People were asked where they had gone within the area, what they had done, what they thought concerning facilities and crowding, something about their personal background, and much more. As far as possible, this sample was spread proportionately over all areas and types of use.

The more detailed data will be related to the use estimates obtained from the roadside work. Maps of intensity of each type of use, of dominant use,

FIGURE 18.—Homeward-bound vacationers tell interviewer about their trip in the Boundary Waters Canoe Area, Superior National Forest.

of areas considered "crowded," and of country viewed as "wild" will be prepared and interpreted on the basis of ideas and attitudes tabulated from the longer questionnaires.

It is hoped that this study, and others broadly similar, will also facilitate future forest recreation research in the Lake States. One of its most important functions will be to provide a basis for planning more localized or more specialized studies, and for applying the results of such studies to larger areas. The benchmark role for assessing trends has been mentioned. Hypotheses and survey methods which can be tested elsewhere will also be developed.

FOREST ECONOMICS

J. T. MORGAN, *Division Chief*

The work of the Forest Economics Division is to make and keep current an inventory of forest resources, to explore better ways of making forest inventories, to find means of overcoming financial and institutional obstacles to greater production of high-quality timber, and to discover economical ways of marketing timber and forest products.

The Forest Survey provides the inventory. Working on a 10-year cycle in most States and in close cooperation with State Conservation Departments, National Forests, Schools of Forestry, other State organizaions, and private industry groups, it collects the basic data on timber supplies, growth, depletion, and prospects for future growth. Final results are analyses and interpretations of current timber stand conditions, and trends of growing stock as related to projected future needs.

But only part of the picture of future productivity can be drawn from the statistics on stand conditions, growth, and timber cut. Other indications are derived from studies of forest landowner's attitudes and intentions. Economics research also seeks to clarify and demonstrate the financial side of forestry in the Lake States by showing: the dollar returns to be expected from different forestry practices; the impact of different systems of protection and taxes, and other costs; and the opportunities to improve marketing, both to utilize surplus timber and to create conditions favoring better growth.

FOREST SURVEY

Publication of final reports on all recent surveys was brought a step nearer completion by release of "Michigan's Forest Resources," Station Paper No. 82. Except for Wisconsin and Nebraska, final reports have now been published for all of the Forest Surveys started since World War II in the Lake States, Central States, and Northern Plains States. Manuscripts for the Wisconsin and Nebraska reports are being reviewed, and publication is expected in 1961.

Fieldwork for the second Missouri Forest Survey, begun 2 years ago, has been completed. The work in Missouri was greatly intensified and strengthened through the cooperation of the State—particularly the University of Missouri. The first unit report, for the Eastern Ozarks area, is undergoing review. In Minnesota, fieldwork is about 30 percent complete; the Office of Iron Range Resources and Rehabilitation is doing the survey on private lands in northern counties, and the Station is covering the more southern counties. Advance plans are being made for surveys in Illinois and Kentucky in conjunction with the Central States Station.

Three aspects of Forest Survey work have received special emphasis in 1960. These are the sampling design and plot layout, area condition classification, and county-by-county compilations of pulpwood production. Each of these is discussed briefly below.

Forest Survey Methods are Changing

Despite 30 years of Forest Survey experience in the Lake States, basic changes are still being made in Survey design and methods. In fact, what amounts to a revolution is taking place. An attempt at standardization of Survey techniques a year or two ago had to be delayed because of the surge of new concepts coming into use. Many of these innovations are on trial in the current Minnesota Forest Survey.

Major changes from previous surveys include:

1. Non-stratified instead of stratified sampling, to permit future inventory by remeasurement of identical plots.

2. Better growth and mortality information by remeasurement of permanent plots established in the 1950's.

3. Angle-gauge (Bitterlich) instead of fixed-radius plots for a substantial savings in costs.

4. Frequency index sampling at a number of points scattered about a sample acre to provide greatly improved area classifications (more on this below).

5. Factor-of-10 angle-gauge subplots for individual tree tally, supplemented by a basal area count on 4 subplots distributed over the acre—to provide an efficient estimate of current volume as well as a permanent sample plot for studying growth.

6. Timber cut information from county-by-county reports on pulpwood sources, cutting reports from large landowners, and a tally of stumps on inventory plots.

7. Special studies of conversion factors and volume-table correction factors to improve both timber cut and inventory statistics.

8. More specific definitions and instructions on estimating merchantable height and cull loss; timber management guides and greater use of basal area to improve estimates of desirable cut.

9. More information on ownership and quality. Quality of sites, stands, and individual trees and logs are now measured or estimated.

10. More emphasis on trends. The new Survey measures not only the net change in land use, but the movement in and out of the forest classification. Recurring surveys using permanent plots provide information on trends in volume, growth, and use of the timber resource.

11. Greater use of automatic data-processing machines to speed computing and report preparation.

Still other changes can be expected when the Survey moves to other States. Intensified forest management on many large ownerships will require new kinds of information. The problem of getting better production from small ownerships will require more detailed figures and closer study. Survey procedures will continue to be modified and adapted to produce results useful to industries and landowners.

Area Condition Classes Introduced

The Forest Survey has long needed a means and a classification system for diagnosing the condition of a forest stand. In previous Lake States Forest Surveys, stand classification indicated the forest cover type, stand size, and density. These classes were useful but did not tell the forester much about silvicultural conditions. For example, an area previously called poorly stocked sawtimber might be completely clothed with tree cover when small trees are considered. There was no indication whether the trees were excellent growing stock or near cull material. Stand-size and density classes were based on volume of merchantable trees or numbers of seedlings and saplings without a good means of evaluating combinations. The impact of cull trees or other inhibiting vegetation was not measured.

A forest productivity classification to measure stand conditions was used in the Timber Resource Review. This led to development of an Area Condition Classification by A. A. Hasel and R. W. Larson of the Forest Service. It consists basically of frequency index sampling of a number of points in a stand to determine stocking of desirable trees and other growth, and provides information for classifying forest type, stand size, and stocking. The Hasel-Larson System was incorporated into the design of the Third Minnesota Forest Survey.

Forest area is determined by examining sample acres on aerial photos and checking a subsample of them on the ground. But one small field plot often will not properly classify the acre in a clumpy or patchy stand. The Station is now using 13 points well distributed over the acre (fig. 19). One point is at the center; the others are laid out on a traverse

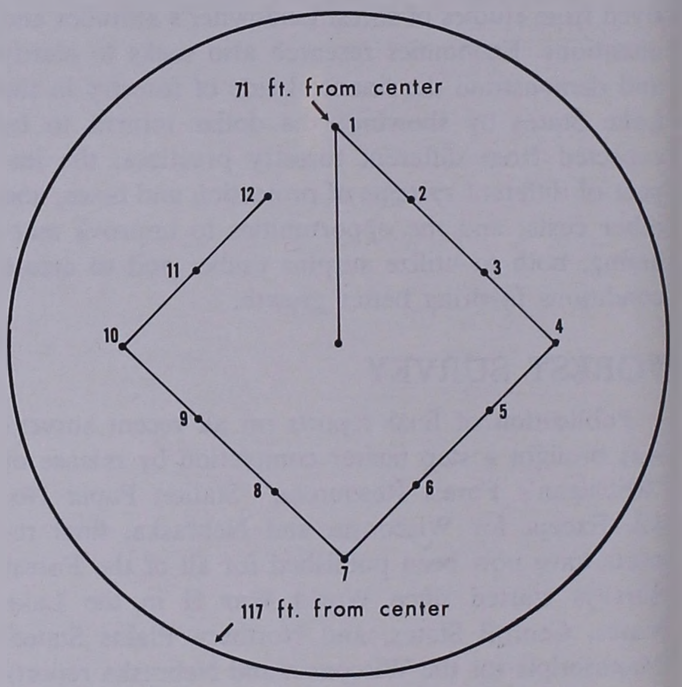

FIGURE 19.—Diagram for 13 point-subsamples on a 1-acre plot.

with points at ½-chain intervals. At each point an angle-gauge (Bitterlich) stick is used to see if any free-growing tree dominates the point. If so, the tree is tallied as desirable, acceptable, or cull. More than one free-growing tree on a point denotes overstocking. If no pole- or sawtimber-size trees are present, small fixed plots of several sizes are used to measure stocking of saplings, seedlings, and inhibiting vegetation. The cruiser also estimates the silvicultural treatment needed at each small point to stock it with a desirable tree.

The tally for the 13 points provides information for classifying the forest stand in either the field or office. It indicates the proportional stocking of desirable, acceptable, and cull trees, and the need for harvest cutting, TSI (timber stand improvement), or regeneration. The tally in table 4 would indicate a medium-stocked sawtimber stand in the aspen type, area condition class 4.[3] Prospective stocking in 10 years, with or without treatment, may be estimated and treatment may be recommended, if desired.

This tally reveals a good deal about the stand. Aspen sawtimber growing-stock trees predominate in a patchy stand. Growing-stock trees control 54 percent of the points, hence constitute medium stocking. Desirable trees stock 31 percent of the area. An adequate seed source appears to be available, and seedbed conditions are generally favorable. However, since this is an aspen site the silvicultural management guides prescribe that the stand be clear cut and the cull trees removed to stimulate aspen suckering. The Forest Survey indicates the primary action, which is a commercial cut within 10 years. The cut-and-leave tally will specify removal of all merchantable trees. Their volumes will be a part of desirable cut.

[3] Area condition class 4 indicates areas less than 40 percent stocked with desirable trees and with adequate seed source and seedbed favorable to natural restocking (less than 30 percent of the area controlled by inhibiting vegetation or surface conditions that will prevent occupancy by desirable trees).

Pulpwood Production Estimated by Counties

Many forest owners and most plant managers are interested in problems of future timber supplies. Rapid changes in the raw material supply may require a revision of industry plans and policies. Forest Surveys establish the supply situation at a particular time, but between surveys an indication of change can be gained from analysis of timber cutting. This helps to show the trend of forest resources in local situations and to point out not only opportunities for increased harvesting but also areas that are being overcut.

In 1960 the Station, in cooperation with the Michigan Department of Conservation, launched an intensified survey of pulpwood production. Pulpmills drawing wood from the Lake States region supplied the amounts of pulpwood cut in 1959 in individual

TABLE 4.—*A sample tally for a Forest Survey field plot; data for trees at 13 points well distributed over the acre*

Data on free-growing tree at each point				Data on any extra free-growing tree at each point	Action needed to stock point with desirable tree
Point	Stocking class	Species	Tree-size		
C	Desirable	Oak	Poletimber	—	No action
1	Inhibiting	—	—	—	Prepare site for regen.
2	Acceptable	Maple	Sapling	Cull maple, sapling	No action [1]
3	Acceptable	Aspen	Poletimber	Acceptable aspen, poletbr.	Cut
4	Inhibiting	—	—	—	Prepare site for regen.
5	Desirable	Aspen	Sawtimber	—	Cut
6	Nonstocked	—	—	—	No action
7	Desirable	Aspen	Sawtimber	Desirable oak, poletbr.	Cut
8	Desirable	Aspen	Sawtimber	Acceptable aspen, sawtbr.	Cut
9	Cull	Oak	Sawtimber	—	TSI
10	Nonstockable	—	—	—	Nonproductive site
11	Cull	Oak	Poletimber	Acceptable oak, sapling	TSI
12	Acceptable	Oak	Sapling	—	TSI

Stocking Class	Percent of Points
Desirable trees	31
Acceptable trees	23
Total growing stock	54
Cull & noncommercial trees	15
All trees	69
Inhibiting vegetation and slash	15
Nonstocked	8
Nonstockable	8

[1] No action needed since a desirable oak pole will be large enough to stock this point in 10 years.

counties. Because pulpwood accounts for about one-third of the timber cut, an annual survey of this product will help to measure the trend of cutting by species in the important timber-producing counties. By working closely with industry and other public forestry agencies, we hope eventually to include other important forest products for a more complete reporting of timber cutting at the county level.

Because the rate of cutting in supply areas changes from year to year, a series of annual data by districts and counties is desirable. Prior to the survey of the 1959 cut, only one county-by-county pulpwood survey had been made in each of the three Lake States. An analysis of the data for the two surveys (appearing in Station Paper 85) points to some rather definite changes in cutting patterns within some supply areas. Although trends probably are not firmly established, they indicate the general direction of pulpwood procurement activity.

A comparison of some of the results of the two surveys is shown in table 5; the maps in figure 20 show the 1959 pulpwood cut per 1,000 acres of forest land by districts.

TABLE 5.—*Pulpwood cut [1] by State and Forest Survey districts for specified years*

Forest Survey district	Pulpwood Cut as determined by		Change from first survey
	First pulpwood survey [2]	Second pulpwood survey 1959	
	Thousand cords	Thousand cords	Percent
		Minnesota	
Northeast	376	392	+ 4
Central Pine	297	381	+28
Rainy River	227	203	−11
Hardwood Prairie	37	18	−51
All districts	937	994	+ 6
		Wisconsin	
Northeast	396	376	− 5
Northwest	317	364	+17
Central	216	189	−12
Southeast Southwest	5	3	−40
All districts	934	932	0
		Michigan	
E½ Upper Pensinsula	191	254	+33
W½ Upper Peninsula	360	353	− 2
N½ Lower Peninsula	219	409	+87
S½ Lower Peninsula	27	32	+19
All districts	797	1,048	+13

[1] Roundwood only.
[2] Dates of first pulpwood survey:
Minnesota—1952
Wisconsin—1956
Michigan—1954

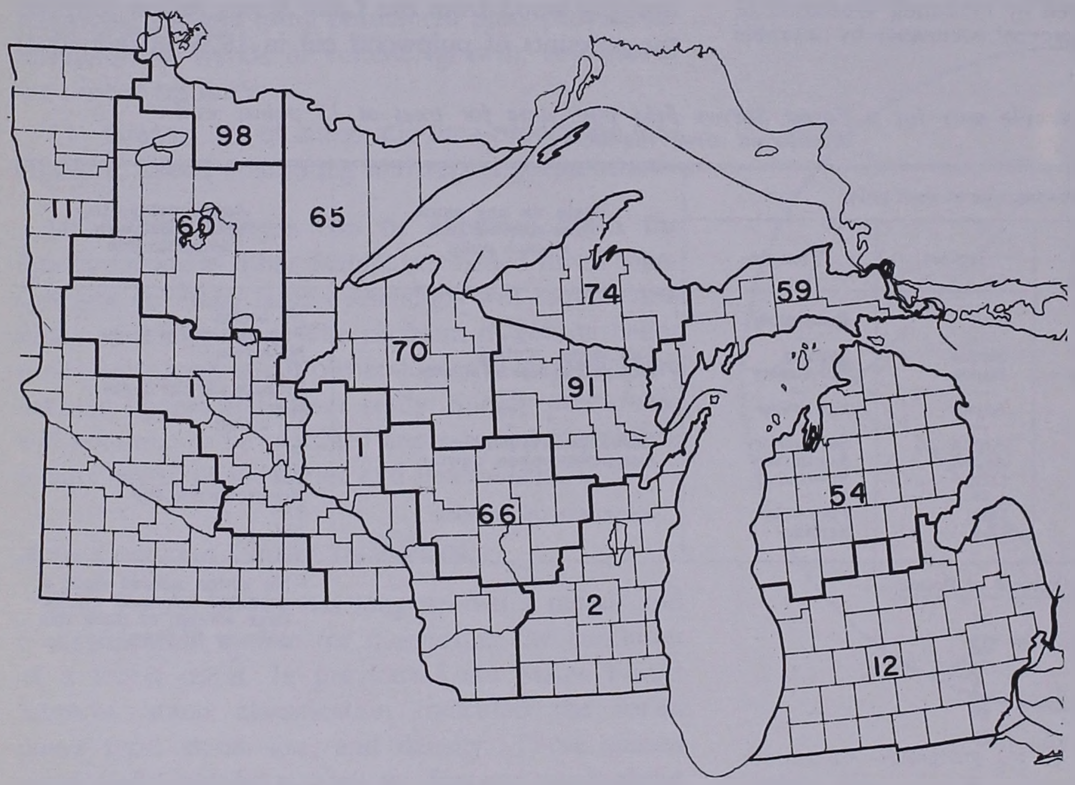

FIGURE 20.—Pulpwood cut in cords per 1,000 acres of commercial forest land by districts, 1959.

ECONOMICS OF TIMBER PRODUCTION AND MARKETING

Economics research at the Station has taken some new directions as the result of program planning over the last 2 years. Previous studies have dealt with the distribution and use of manufactured or partially processed products. This is an important problem area where much investigation is needed; in the final analysis, "demand" sets the levels for production under management. But production problems on small ownerships and on the public lands are critical and close to home. Informed decisions made in the 1960's will help to improve the timber supply and the regional economy in the 1980's and beyond.

During the past year the Station reported on studies of forest taxation in Wisconsin, farm lumber consumption in Minnesota, and charcoal marketing in Wisconsin. In the field of forest production problems, progress was made toward predicting incomes from timber growing and on surveys of forest owner attitudes. We expect to continue and expand our analyses of the economic returns from different timber management practices. New studies related to ownership will concentrate on specific opportunities to encourage more valuable production on small holdings. Market development, pointed toward areas of surplus timber, will receive increased attention.

Forest Taxes and Income Compared

With the Wisconsin Conservation Department, a study was made of the effect of property taxes on income from forest lands. The area chosen was northeastern and central Wisconsin, and the main objective was to analyze the impact upon net income of both the yield tax (Forest Crop Law) and the general property tax.

After projecting net returns from nine typical properties over a 50-year period, the conclusion was that in most cases the existing tax burden upon forest owners, when related to the earning power of the forest, appeared to be excessive. Little or no evidence was found to support a tax increase. Additional results of the study showed that tax revenue under the Forest Crop Law was less than that under the general property tax, but that the gap is closing as timber growth increases on the Forest Crop Law lands.

Confirming the results of earlier work, it was found that forest land is usually assessed at a higher percentage of its full market value than are other classes of real estate. Distance of the owner's residence from his forest holdings, and size of forest tract, appeared to have little influence on the level of assessed values, but value of timber did have. These results point to the need for reassessment of taxing procedures as they apply to forest land and for further efforts to devise equitable means of taxing forest properties that will not eat up the expected revenues.

Small Private Owners—a Numerous and Varied Group

Although the Lake States have large areas of public forest land, small privately owned forest lands are important in the forest resource picture. Such lands amount to 83 percent of the private and almost 50 percent of all commercial forest lands in Michigan, Minnesota, and Wisconsin. The bulk of them, although defined as including all private landowners with less than 5,000 acres of forest land in total, is made up of ownerships much smaller than this maximum size. Of the area owned by this group 94 percent is held by owners having less than 500 acres each, and over half by owners with less than 100 acres.

Because these forest lands are a significant part of the Lake States forest resource, the Station during the past 6 years has made, or cooperated on, studies designed to learn more about the identity, forest practices, and land management problems of this diverse ownership group. The most recent studies—one in southern Michigan and one in Michigan's Upper Peninsula—are now being anaylzed prior to publication. An earlier study made in central Wisconsin in 1959 was published as Station Paper 77, while another, made in cooperation with Michigan State University in 1954, covered the northern half of Michigan's Lower Peninsula and was published by the University.

All four studies point up the importance of analyzing small private forest landownership practices and problems in terms of not only the forest resource itself but also the economic, social, and physical environment existing in the particular time period.

While merchantable timber and active markets are necessary to provide a flow of timber products from such lands, other factors such as age and physical condition of owner, employment and income opportunities, and objectives of landownership also may influence the owner's decision to market timber or engage in any other forest management activity.

Changing patterns among these small ownerships will create a need for re-evaluation in planning and programs on the part of agencies seeking to improve the management of small woodlands. The two most recent studies indicate that in Michigan the majority of small private forests can no longer be considered as farmer-owned woodlands. The southern Michigan study, covering a 37-county area, disclosed that 68 percent of these small woodland owners were not farmers; in the Upper Peninsula the proportion was even larger—83 percent. These findings parallel a similar predominance of nonfarm ownership found in the 1954 northern Lower Peninsula study.

Data from the southern Michigan study show that 20 percent of the small woodland owners in that area either had already sold a portion of their wooded holdings for urban or industrial use, or had been approached by individuals interested in purchasing lands for such development. As this pressure will mount with continued population increases, it seems likely that future urban expansion will preclude timber production in some areas of southern Michigan. In the Upper Peninsula the opposite is true. Here it appears that changing land use will cause some rise in forest acreage. From 1954 to 1959 the number of active farms in the Upper Peninsula declined by 34 percent. While the Soil Bank has accelerated this decline in farming, the trend was under way long before the start of this program. Some of these idle farms may come back into agricultural production, but many others probably never will be farmed again. Such lands add to the large areas in the Lake States already in need of reforestation.

In addition to these changes and their implications, the studies show a considerable rise in absentee ownership in the northern Lake States. The increasing prominence of this group, primarily motivated by recreational use, will demand new approaches by public and industrial service foresters, timber buyers, and others dealing directly with small owners. Existing techniques are not as likely to reach these owners, who visit their properties at infrequent intervals. Some absentee owners interviewed said that they would be willing to sell merchantable timber from their properties but no one had ever approached them concerning a sale. Many others knew nothing of available forestry assistance programs.

Knowledge of who these small owners are, their ownership objectives, woodland practices and problems, and typical responses to available forestry programs can help to ensure that the more than 26 million acres of commercial forest land held by such owners in the Lake States do make a substantial contribution to the forest economy of the region.

Red Pine Managed for Increased Profit

The intensive management of some timber species, such as red pine, yields products for sale periodically, beginning at an early stand age. The volume and value of these products depend not only on the productivity of the site and market conditions but also on how the forester manages the stand. By his choice of timing, intensity and method of cutting, selection of harvest age, and other management decisions, he can greatly influence the size and timing of returns.

In 1960 the Station began a study of the economics of timber production under even-aged management. The aim is to develop methods of evaluating from an economic viewpoint some of the different ways of managing even-aged timber stands. Methods of comparing forest management investment opportunities are necessary for forest owners and managers. A report, which shows a method of graphing the rate of return on investment for a range of land costs and stand establishment costs for specified sites, stumpage prices, annual costs, and other management conditions, will be published in 1961. A similar technique has been used to present information on investment return from pine release.

One phase of the study is producing a set of red pine *value* yield tables, developed for a range of sites, ages, stand densities, and stumpage prices. These were based on *volume* yield tables for intensively managed stands. The volume yield tables had been recently constructed from growth and yield information collected on management studies over the past 30 years.

Another phase of the work in timber production economics involved an economic analysis of three pine release studies; this was completed the past year. In some instances, releasing an established

stand of pine from an overstory of aspen, birch, and other hardwoods affords one of the best investment opportunities in forest management. As figure 21 shows, the average diameter of white pine increased

FIGURE 21. — These white pine cross-sections illustrate the change in average diameter at breast height 22 years after the release of a 28-year-old pine stand from an aspen-birch overstory. Left to right, they represent the tree of average diameter for the stand given no release, partial (crop tree) release, and full release. These three trees all were the same diameter at the time of release.

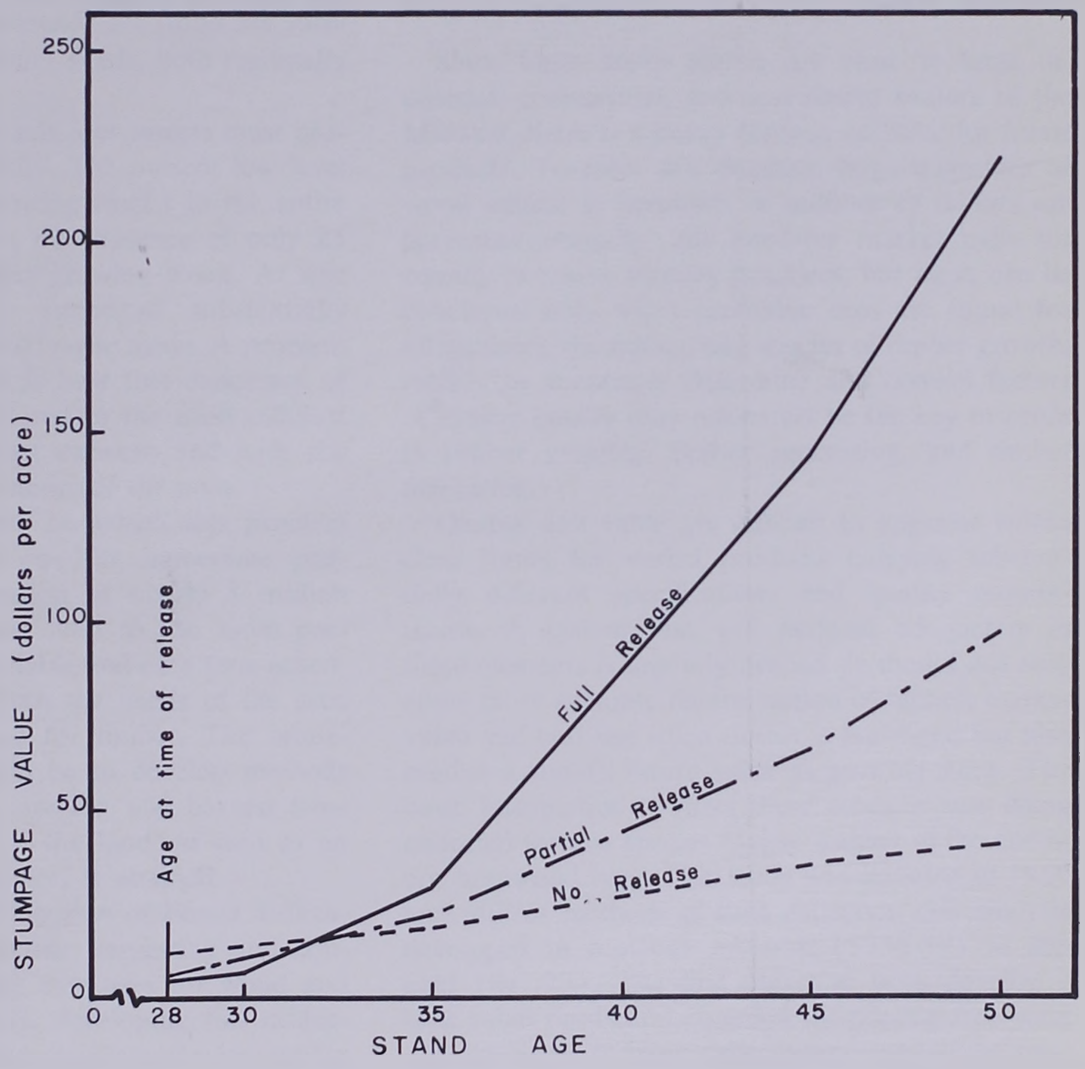

FIGURE 22.—Stumpage values of white pine stands given no, partial, and full release treatment at age 28 (Squaw Point Road white pine release plots; stumpage prices: pine $25 per thousand board feet; conifer cordwood $3 per cord; hardwood $1 per cord).

markedly following release from an overstory of aspen. Twenty-two years after release, the timber values of the fully and partially released stands were $222 and $97 per acre respectively, while the stand given no release treatment was valued at only $41 per acre (fig. 22).

During the 5 years preceding the last measurement of this study, the fully released stand increased in value at an average rate of 9 percent annually, the partially released stand at a rate of 8 percent, the no release stand at a rate of only 3 percent. Thus the difference in value between the white pine stands released from aspen and the stand not released will be even greater in the future. The investment analysis of this and two other pine release studies in northern Minnesota indicates what rate of return can be expected under similar conditions from investments in release for a range of release costs and stumpage prices.

Methods of Estimating Farm Lumber Consumption

A study of farm lumber consumption, done in cooperation with the University of Minnesota, is nearing completion; the first report should be published in 1961. Lumber used on farms amounts to 21 percent of all lumber used for construction. A knowledge of the trend of this use is required for making predictions of future demand and for analyzing market opportunities.

The Minnesota study was designed to test methods of estimating farm use of lumber—to determine sampling and analytical methods that would efficiently measure quantities by species, grades, dimensions, and purposes. Records of survey costs were kept and improvements were suggested for future surveys. Methods and costs are covered in the first report. A second publication will describe actual findings of a trial survey made in Census Economic Area 4 (east-central Minnesota) to test the methods devised.

FOREST UTILIZATION

A. W. Toole, *Division Chief*

The long-term economic prosperity of the northern forest area of the Lake States is dependent largely upon the permanent productive capacity of its 40.7 million acres of commercial forest land. An analysis of forest utilization research problems in this area indicates that a higher level of manufacturing offers the best means of increasing economic opportunities and per-capita income, both of which are now substantially less than in other parts of the three States. In the northern forest area, wood is the most likely source of raw material for increased manufacture. Furthermore, increased demands for wood are forecast for immediate and future needs, both regionally and nationally.

But to meet these demands, our forests must produce to their fullest capacity. The present low level of forest land capital (growing stock) in the entire Lake States is reflected in the presence of only 25 billion cubic feet of timber growing stock. At one time the land originally supported substantially greater amounts, and it could do so again. A problem of major proportion then is how this deficiency of forest capital may be restored to the most efficient operating level at the least expense and with the greatest benefit to the economy of the area.

There are several fronts on which this problem might be attacked. But one for immediate consideration is the regeneration of nearly 8 million acres of nonstocked forest land to the most productive timber species available and on a time schedule commensurate with both the needs of the area and the projected demand for timber. The immediate objective here should be to develop methods and equipment to plant, care for, and harvest trees so that full productivity of the land, as well as an adequate return to the owner, is attained.

Responsibilities of the Division of Forest Utilization include improving timber harvesting and conversion techniques, finding new uses for wood and improving its serviceability, developing full utilization for presently little-used species and poor-quality trees, and conducting research in timber growth and quality relationships.

Pioneering will be required in many aspects of the problems. The necessity for more thorough engineering research into all phases of multiple use forest management grows apace as the relation and interdependence between uses becomes increasingly apparent. Some of the work now underway in the Division is described below.

A Tree-Grading System for Northern Hardwoods—Progress Reported

Since Lake States forests are close to large industrial, commercial, and consuming centers of the Midwest, there is a heavy demand on them for forest products. To meet this demand, large quantities of wood valued in hundreds of millions of dollars are harvested annually. An intensive market calls for equally intensive forestry practices, but these can be developed only when profitable uses are found for all qualities, quantities, and species of timber growth. Ability to accurately determine and control factors of timber quality may ultimately be the key to profit in timber growing, timber processing, and timber marketing.

Quality and value are difficult to appraise within close limits for varied products carrying substantially different specifications and quality requirements. A system that will perform adequately in these elements is urgently needed. It should not only allow more accurate determination of highest market value and best use when timber is harvested but also predict a stand's future value as growing stock. The basic information to meet these needs is now being collected for one species (sugar maple) of the northern hardwood type. This study was initiated in 1960 and utilizes methods of data collection and analysis developed in previous research (1956-59) in this field (fig. 23). The first objective is to develop a true value prediction equation by relating tree stem characteristics to basic value components of the tree.

A second objective is to compile a defect manual for this species which will provide photographic and tabulated records of the relationships between exterior defects and the underlying wood. Results of the study, when completed, will be available as tree-grade systems. Or they can be used along with field-punched data cards for electronic computer processing to provide greatly expanded information.

stems were bucked into 8-foot logs (to facilitate handling) and identified as to tree number, log position, and top ends. The logs were transported to the Ford Forestry Center of the Michigan College of Mining and Technology at Alberta, Mich., for complete photographing and dissection.

A 2-inch-thick disk was cut from the butt of each log and sent to the Forest Products Laboratory at

FIGURE 23.—Method of collecting data relating exterior defects to wood quality.

For the study, four 45-tree samples of northern hardwood stands will be selected—two in Upper Michigan and two in north central Wisconsin.

Much of the work on the first sample in Upper Michigan has already been done. The trees selected had diameters at breast height ranging from 11 to 26 inches. To assure coverage of the tree-quality range, the sample included three tentative quality classifications based on the number of defect-free quarter faces in the butt one-quarter of the stem. Standing tree data included d.b.h., crown class, and lean; after felling, crook and sweep were measured. The

Madison, Wis., where age, growth rate, specific gravity, and machinability will be determined. On each log end were routed the four-face division lines and a circle with a diameter equal to one-half the log diameter. These marks provided for the relocation of faces and zone lines after sawing into flitches. Hidden defects were considered only in the outer circle zones.

All log exteriors and exterior defect indicators were photographed and numbered consecutively for each tree. Each of the four faces and a diagram board with defect numbers were photographed to

provide a record for tracing individual defects into the interior of the logs after sawing. In addition, extreme closeup color photographs were taken of all exterior defect indicators—2,600 altogether for the 45 trees.

The logs were sawed, without turning, into 1-inch-thick flitches, each of which was marked with tree, log, face, and flitch number. All defects were also marked and identified, where possible, with the number of the corresponding exterior defect. The flitches were then photographed in color. Closeup photographs of selected interior defects were taken.

The transfer of information from the projected flitch images to punchcards will be done at the Station's Wausau field unit. A color-slide viewing device, utilizing the rear projection method and a special screen (30 inches by 102 inches) mounted on 3/8-inch-thick plexiglass, will be used. The values of the wood and the measurements of the various stem characteristics will be obtained from the projected slides. The data will be analyzed by multiple correlation on electronic computers capable of handling as many as 15 independent variables. In this manner the relationships between the tree stem characteristics and wood value will be determined, and from this an estimating equation will be obtained for application to field data.

This study will test for geographical differences within the range of sugar maple in the Lake States; if none exists, a single tree-grading system for the region will be devised. Once a system has been established for sugar maple, the study will be expanded to other important northern hardwood species such as yellow birch and basswood.

Planned Charcoal Kiln Studies Completed

Production of charcoal in kilns has recently become a small but well-established industry in the Lake States, although for many years prior to 1956 there had been but one small kiln operating in the region. Kilns, however, still account for only a minor portion of the area's total volume, which comes largely from plants recovering wood chemicals in the production of charcoal.

In 1955, in response to numerous requests for detailed technical information on kiln production, the Lake States Station, in cooperation with industry, educational institutions, and other Forest Service research groups, initiated a research program in this field. Field experimental work was largely completed in late 1959, and some early results have already been published. A comprehensive report on the work at this Station, the Southeastern Forest Experiment Station, and the Forest Products Laboratory will probably appear late in 1961.

Field installations were established at Dukes Experimental Forest near Marquette, Mich., and Argonne Experimental Forest, Three Lakes, Wis.

The study at Dukes sought to determine the economics, or breakeven point, in an integrated operation of timber harvesting, stand improvement, and charcoal production. It was found that charcoal production in conjunction with timber stand improvement cuttings would reduce costs of the latter by as much as $3.55 per cord over no utilization. The following tabulation summarizes the costs of timber stand improvement on a 40-acre tract with and without a charcoal kiln operation.

With charcoal operation		
Total value of charcoal sales		$3,372.05
Cost of cutting material	$1,004.25	
Cost of transporting material	1,143.30	
Cost of kiln operation	1,680.96	
Total costs		3,828.51
Loss on charcoal operation		456.46
Credit for stumpage sale		472.72
Total profit on timber stand improvement operation		16.26
Without charcoal operation		
Stumpage sale		472.72
Cost of timber stand improvement		1,004.25
Loss on timber stand improvement operation		531.53

Thus, the charcoal operation actually enabled the landowner to show a small profit on his timber stand improvement work, whereas without it he would have been over $500 out of pocket.

At the Argonne Experimental Forest the principal objectives were to develop economical designs for small kilns and obtain information and data on the variables of the kiln process and raw material.

Three small kilns were built to study low-cost designs, composite wall constructions, and materials for lining kiln chambers. Initial performances indicate that under the design conditions studied, the corrugated sheet metal and castable refractories can provide an economical and satisfactory material for kiln chambers. The composite wall design used in combination with cinder-concrete lining proved to

be unsatisfactory. In the series of 54 experimental burns conducted in these kilns, several techniques applicable to common operating practice were tested and found helpful in meeting objectives of low-cost mechanization and more scientific control of the kiln process: (1) Ignition of the charge with a gas- or oil-fired torch, (2) ignition and air entry at one central point in the charge with chimneys located at each of the four corners of the kiln, (3) mechanical control of the air supply, (4) process control by temperature measurement, and (5) predrying the kiln charge.

Preservative Treatment and Design Create Improved Farm Buildings

From earliest settlement of this nation, wood has been a favored structural material for use on farms. Its ready availability and low cost and the wide selection of species for strength, resistance to decay, ease of working, and appearance, were all factors in its favor. Today other structural materials offer strong competition for this large market, often at higher cost and lower serviceability. In this competition, wood has suffered because of the use of nondurable species without preservative treatment in situations favoring decay. Research in preservative treatment and use of wood on farms thus offers opportunities for increased serviceability to farmers and expanded markets for wood producers. Cooperative studies have been carried on in this field with the University of Minnesota School of Forestry and other University departments for a number of years.

Under this program several major livestock buildings, incorporating improved functional and structural design with preservative treatment, have been constructed by the University at its Rosemount Research Center and tested under operating conditions. Reports in 1960 covered a 5-year test of an economical, insulated, and ventilated pole-frame hog farrowing house and two 26x98-foot "inside-out" pole-frame cold buildings for use on the hog project (fig. 24).

The farrowing house kept an acceptable 50° F. winter temperature from animal heat plus a limited amount of furnace heat, while ventilation with fans prevented atmospheric moisture condensation on walls and ceiling. Under intensive summer use, this building has remained cool and dry. Only the untreated exterior control panels in the structure show evidence of decay. While wood preservation cannot be substituted for proper design and construction practice and the proper use of vapor barriers, insulation, and ventilation in warm animal housing, it does permit use of wood of nondurable but treatable species for maximum service and lowest cost.

Penta-treated jack and red pine poles were used in both of the cold-type buildings. Douglas-fir lumber was used exclusively in one, red and jack pine lumber in the other. The lower side-wall boards were given a heavy penta treatment. The remainder of the wall boards and the rafters and roof boards were given a 3-minute dip in a 5-percent water-repellent penta solution, with mineral spirits as a solvent. Untreated control panels were left in the roof. Both

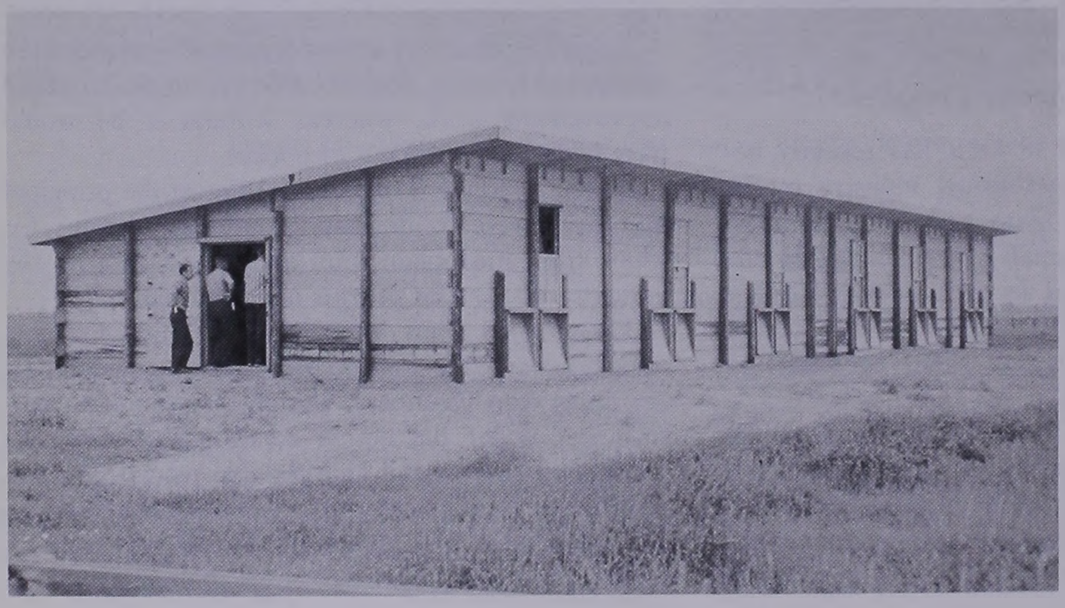

FIGURE 24.—An "inside-out" pole-frame hog barn, constructed with local (Minnesota) pine.

FIGURE 25. — Pile of logs sprayed continuously on top and ends from April 20 to October 6, 1959. For this and the other sprayed piles, 3/4-inch plastic pipe and wide-angle nozzles of the roof-cooling type were used.

design and preservative treatment will be studied in these buildings.

Special construction features include the use of 2-inch tongue-and-groove lumber for side walls, attached to the *inside* of the poles. This leaves a smooth inside surface for the building. Corners were built like those in a log cabin, with a triangular section bolted through the walls to the corner pole for strength. There is no other bracing in the building. The rafters rest on and are attached to the side walls by 2x2 nailing strips. The rafters also rest on a center purlin, which in turn rests on the top of the support poles. Windows open and close on the outside of the building. Cost of this building is about the same as for a regular pole-frame building.

Wood Loss Reduced by Spraying Winter-Cut, Stored Logs

Decay and stain are important sources of waste or degrade in hardwood logs decked on storage yards and held during warm weather. The stain problem is particularly serious in high-value hardwood veneer logs and may occur as chemical (nonfungus) and fungus discolorations. Spraying decked logs with water has been used to a limited extent to protect western softwoods and northern hardwoods from stain, decay, and end-checking, but little has been known about the effectiveness of spraying to prevent chemical or oxidation stains in hardwoods.

A study to determine the effect of water spraying on winter-cut logs of four important hardwood veneer species (yellow birch, white birch, sugar maple, and soft maple) was begun in 1959. Cooperating with the Station were the Forest Products Laboratory and the hardwood veneer manufacturers of Wisconsin and Michigan. The study was conducted at the plant of the Frost Veneer Company, Antigo, Wis. The tests included continuous spraying on all log surfaces, continuous spraying on ends only, intermittent spraying on top only on a 6-hour cycle, spraying on a 12-hour daytime-only basis, and a control in which no spraying or protection was afforded (fig. 25). The effect of delayed spraying was determined by adding winter-cut logs of each species to the continuously sprayed deck on May 15, June 1, and July 1.

Sample bolts were cut into veneer at the conclusion of spraying in October. Observations were made at depths of about one-third and two-thirds of the sapwood, since no detectable changes occurred in the heartwood. The sample at each point consisted

FIGURE 26.—Outdoor storage piles of chipped northern hardwood logging residue.

of two sheets of one complete revolution each. Since stain and decay damage are most significantly associated with the log ends, observations were confined to the 45 inches of length from each end.

All unsprayed logs suffered severe loss and degrade. But chemical and fungus stains and decay were readily controlled by continuous and complete spraying during warm weather storage in the four species tested. Some latitude may be available in the amount of wetting afforded; intermittent cycles were satisfactory if the spraying was frequent enough to keep log ends and surfaces continuously wet. Wintercut logs may apparently he held until about May 15 in north central Wisconsin without harm.

Maximum Outdoor-Storage Time Determined for Hardwood Chips

Experiments in the utilization of hardwood logging residues through conversion to bark-free chips were continued by the Michigan College of Mining and Technology in cooperation with the Station. The purpose of the study was to investigate the effect of outdoor storage of piled hardwood chips on the ease of bark removal and the extent of any preferential decay of bark that might occur. Two free-standing (conical) piles of hard maple chips were made in each of the four seasons of the year; the ships came from freshly cut tops, limbs, and cull material developed in normal logging operations (fig. 26). One pile was 6 feet high and the other 12 feet high to measure variations that might be due to depth and compaction. All tests were completed in 1959.

Although periodic sampling showed bark content as low as 6 percent compared with approximately 13 percent for the material before chipping, no evidence of "preferential decay" was detected. Rather, the decrease in bark content seemed to be due to mechanical reduction of bark to fine particles in chipping so that much of it could be screened out with the fines. The older piles (up to 18 months) show considerable wood decay. Apparently hardwood chips cannot be stored outdoors in this region more than 8 months without danger of wood loss through decay. In that time considerable discoloration of chips occurs to a depth of about 18 inches. This discoloration can be bleached out chemically.

Bolter Saw Utilizes Logging Residue

Cooperative studies with the University of Michigan to improve both the production in primary wood processing operations and their economic stability

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were continued. A bolter saw was used to process material not ordinarily utilized in hardwood logging operations in southeastern Michigan, and to determine yields and quality of furniture flats and squares that could be sawed from this residue. Basswood study bolts (1,300 board feet) from 30 to 60 inches in length and 7 to 17 inches in diameter, obtained as residues from a commercial logging operation, were diagramed, graded, and sawed. Yields were graded under National Hardwood Lumber Association rules and converted to dollar values per thousand.

Sawing on the bolter was quite accurate, with only 2.5 percent (32 board feet) not meeting the sawing standards established for the study. Board-foot yield was 1.2 percent less than the log or bolt scale. Values in dollars per thousand board feet were calculated from the expression $Y = 189.55 - 26.69X_1 + 8.99X_2$, where X_1 is bolt grade and X_2 is bolt length in feet. Cumulative recovery product values in terms of diameter and grade were also determined. Results of this study were presented as the thesis requirement for the Master of Science in Wood Technology degree, University of Michigan.

FOREST INSECTS

H. J. MacAloney, *Division Chief*

The forest insect research program includes research, surveys, and technical assistance for control projects.

Much of the research begun within the past 5 years on two major pests, the spruce budworm and the European pine shoot moth, has now been completed or is in the final stages. As these projects have progressed, other studies have been established including the poplar borer, the Zimmerman pine moth, and improvement in survey techniques. In 1960 an investigation of the forest insects and diseases in the Northern Great Plains was begun in cooperation with the Division of Forest Disease Research. Work on a less intensive scale (chiefly because the time element and manpower problems have prevented greater attention) has been conducted on seed and cone insects, jack-pine budworm, white-pine weevil, and pulpwood borers. Results, in published articles or progress reports, have been made available to cooperators.

More effective surveys have uncovered potentially serious infestations and have accentuated the need for greater attention to detection and appraisal of developing populations. With increasing awareness of the depredations by insect pests, forest managers are seeking advice on control more frequently. The survey and technical assistance work has been an important phase of our field activities.

Closely allied with the assistance rendered on specific problems is the training work done by the Division. This year staff members presented information on life history, habits, and identification of the principal forest insects of the region at two meetings, sponsored by the Forest Service Regional Office, for ranger staffs and industry men. We were also called on to present similar information at training meetings held by other agencies.

SPRUCE BUDWORM

The history of infestations by the spruce budworm shows it to be the most damaging pest of our spruce-fir forests. The current severe outbreak in northern Minnesota is only one of several over the past century in the United States and Canada that have destroyed millions of cords of pulpwood timber. Although effective insecticidal control measures have been developed and are being used in some of the more severely damaged areas, the best solution to the budworm problem in the long run would be silvicultural and cutting practices designed to produce a forest resistant to attack and damage. Before we can develop practical measures of this sort, however, we must know the underlying factors that regulate budworm populations. It is on such basic knowledge that the Station has been concentrating its budworm research since 1955.

Some of the more fundamental problems are: (1) the influence of stand conditions on the habits of the insect, (2) the limitation of degree of attack through cutting practices, and (3) the stand conditions that make natural factors more effective. Their solution is not simple and we cannot expect immediate answers—in fact, the final answers will probably come only when the present outbreak has run its course.

Nevertheless, many of the biological and ecological studies have been completed, and we feel we have made real progress. Some of the results obtained so far are here described.

Populations Not Greatly Reduced by Parasites

Studies to date have shown that natural factors have not changed spruce budworm populations in northern Minnesota significantly. Field data for 1960 indicate that parasitism is still unimportant; for all stages examined in the four biological study areas it varied from 50 to 68 percent, a slight increase over that in 1959. Although parasitism over the past 5 years has been relatively stable, some species have exhibited differences. For example, parasitism of eggs (fig. 27) has remained fairly

constant—approximately 5 percent—while that of the late larvae (fig. 28) has been quite variable, ranging from 15 to 50 percent. Pupal parasitism has been somewhat less variable. As yet, parasitism apparently has not reached the critical point that foreshadows a decline in the infestation. As would be expected, it has been more noticeable in those areas where high budworm populations have been present for several years.

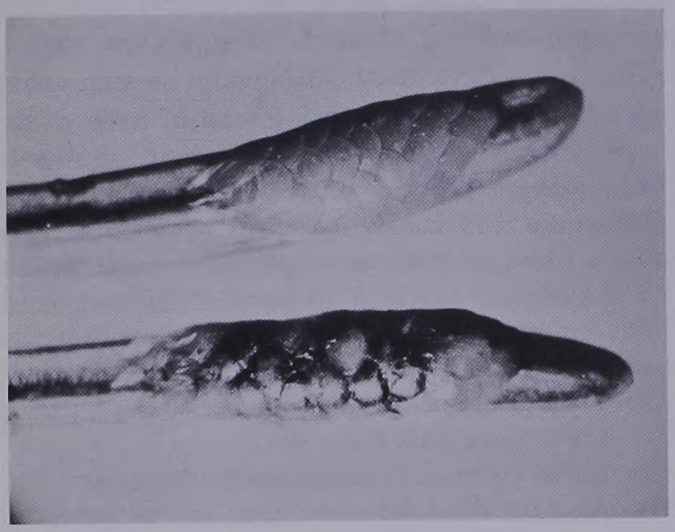

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FIGURE 27.—Spruce budworm eggs magnified several times. *Top*, normal; *bottom*, parasitized by *Trichogramma minutum*.

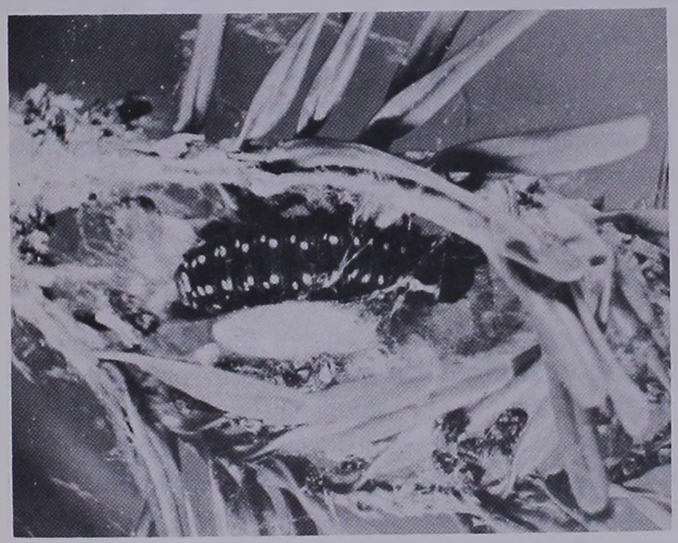

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FIGURE 28.—Cocoon of a larval parasite, *Meteorus trachynotus* Vier., attached to side of a mature spruce budworm; magnified several times.

Collections of budworms in two areas sprayed in 1960 were reared for data on parasitism. Most of those surviving the spray were parasitized, the early larval parasites, *Glypta* and *Apanteles,* being most numerous. Only an occasional late-larval species was reared from these collections. It is, therefore, apparent that the spray was applied before the late-larval parasites are normally active. This points up the critical problem in timing aerial insecticidal applications so that natural factors, such as parasites, are not affected by the insecticide.

Diseases of Minor Importance to Date

The importance of naturally occurring diseases in materially reducing certain insect populations has long been recognized. So far, these natural pathogens have not been observed in the Minnesota infestation. Some unexplained mortality of early larvae has occurred, but only organisms of a saprophytic nature were recovered. The same results have been obtained from an occasional dead larva and pupa found in the field. The possibility that these organisms may become more evident as population density increases is recognized. Current studies will be expanded to give particular emphasis to this mortality factor.

Overwinter Mortality Consistently Low

More than three-quarters of the budworm's life cycle is passed in the hibernating stage. In Minnesota during this period mortality has been consistently low, about 10 percent annually, and appears to have little relation to climate or other external influences.

Larval Competition—an Important Population Density Factor

Under epidemic conditions competition for food is an important factor that is related to population density. Larval mortality results from starvation and from wandering and dropping of the late-instar larvae in search of food. Areas in Minnesota adjacent to the Canadian border have suffered 3 or more years of severe defoliation. This annual reduction in foliage has been reflected in a noticeable reduction in the budworm population throughout these areas, undoubtedly due to starvation. However, the lower population density does not necessarily mean

a decline in the outbreak; severe defoliation can continue as fewer larvae are needed to remove the sparse foliage produced by these weakened trees.

White Spruce Preferred for Egg Laying

Host choice studies were terminated this year. Certain strong tendencies were evident, white spruce being preferred over balsam fir for oviposition. Thirty-five branches, comparable in size and location, from a white spruce tree and an adjacent balsam fir were sampled. On the white spruce 436 egg masses and 58 female pupal cases were found, whereas the totals from the balsam fir were 168 and 38 respectively. When 50 pairs of moths were placed in cages with one 3-foot branch each of white spruce, balsam fir, black spruce, and tamarack, twice as many egg masses were deposited on white spruce needles as on those of balsam fir. Balsam fir had nearly twice as many masses as black spruce or tamarack, species known to be less desirable for budworm development. Field tests, involving white spruce and balsam fir branches of similar size tied in a balsam fir tree, revealed twice as many egg masses on the white spruce branches after 7 days.

Direct olfactory studies were made by allowing females to oviposit on simulated needles over petri dishes containing crushed needles of balsam fir, white spruce, and black spruce in water. A fourth dish contained water as a control. Generally, white spruce was preferred over the other species.

Growth Reduction and Mortality Data Accumulating

The study of mortality and growth loss due to the spruce budworm is progressing very satisfactorily. Several plots were established in 1957 and have been sprayed annually to prevent defoliation. These were paired with similar plots left untreated. No defoliation has occurred in the sprayed plots, and mortality has been low. So far top mortality has appeared in all the untreated, defoliated plots, and some have suffered four times the basal area loss occurring in the sprayed areas. The difference in growth loss and mortality between the untreated and the treated plots is attributed to damage by the budworm; mortality and growth reduction caused by other factors is presumed to be the same for both plots in a pair.

Spruce Budworm Can Injure Young, Vigorous Balsam Fir

Research on the spruce budworm has shown that reproductively mature balsam trees generally present conditions more favorable to survival of overwinter-

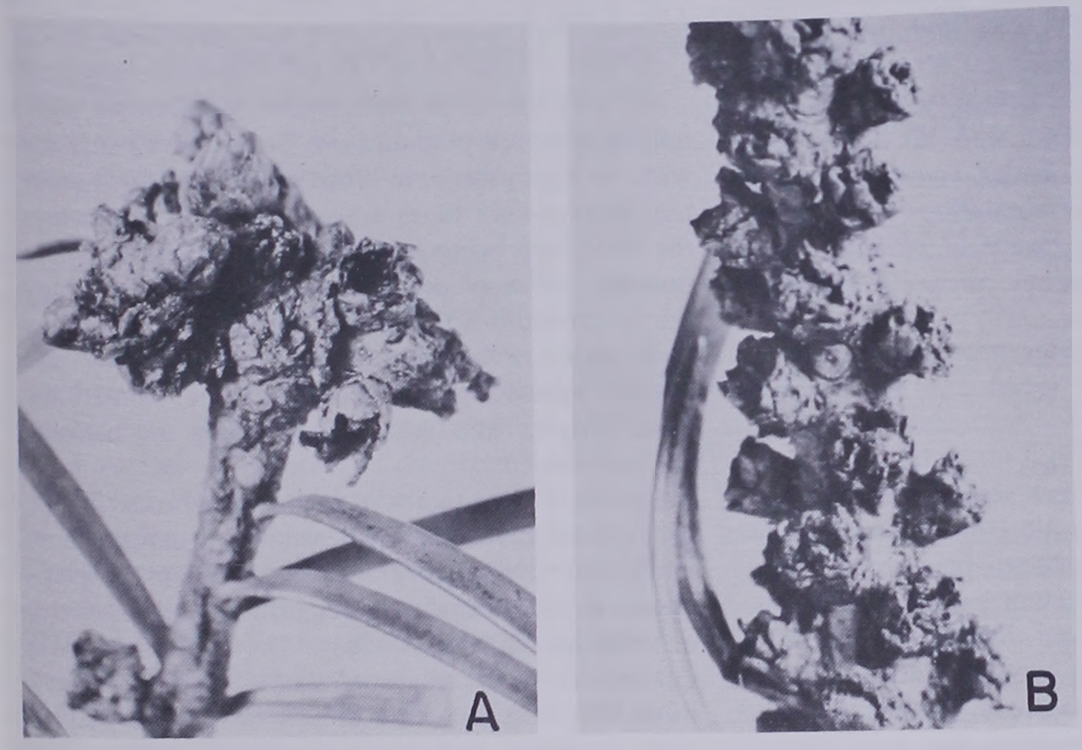

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FIGURE 29. — Balsam fir twigs showing similarity between (*A*) vegetative buds hollowed out by spruce budworm feeding and (*B*) empty staminate flower bracts; magnified several times.

ing larvae than do trees in a nonreproductive condition, and that nonflowering, immature stands of balsam are less vulnerable to the budworm. However, during the present outbreak there have been exceptions to this generalization. Several areas on the Superior National Forest with advanced-growth balsam only (trees 1 to 3 inches in diameter breast height) were found to be heavily infested for 4 successive years.

No trees in the area had borne staminate flowers. Examination showed numerous vegetative buds hollowed out by heavy budworm feeding and used as overwintering sites for the budworm. These buds bear a striking resemblance to staminate flower bracts, which are so favorable for overwintering survival on mature trees (fig. 29). Further investigation is planned to determine how this situation comes about and how management of balsam fir stands might be affected by this type of budworm activity.

EUROPEAN PINE SHOOT MOTH

As plantation acreages increase year by year—a necessity if our forest land is to be brought into full production—the importance of research in plantation pests increases. One of those causing heavy damage to young pine plantations is the European pine shoot moth. For the past 5 years the Station has been conducting biological and insecticidal studies on this pest.

The insecticidal treatments developed so far, however, give satisfactory results only if heavy and costly dosages are used. A better approach to this problem is prevention or limitation of damage through cultural measures, choice of planting sites, or natural control. Considerable progress has been made in this direction.

Tree Growth Conditions Affect Severity of Damage

It is a common belief that serious tree damage occurs within 3 to 5 years after first infestation of pine plantations by the European pine shoot moth. Recent studies, however, show that many plantations are infested for years without damage. Also, badly damaged trees can recover, and "islands" of normally growing trees exist in the midst of otherwise seriously affected areas of plantations.

Recent studies indicate that severe attack is usually associated with slow tree growth, while unattacked trees apparently grow rapidly. The variation of damage with tree growth rates indicates the importance of site quality, especially the soil-root aspect.

Shoot moth damage is a regular feature on some types of soils, while on others it is sporadic or nonexistent. A relation appears to exist between the severity of damage sustained by red pine trees and the nutrients and moisture of the site.

The importance of nutrients has been shown by severe damage occurring regularly on all soil series eroded to the C horizon. The importance of soil moisture was revealed by sporadic damage during drought years on soils where red pine had shallow roots, a condition due to hardpans or water tables that are normally high. Sporadic damage also occurred on deep sands with low water-holding capacities. Lightly infested red pine growing on soils with high moisture-holding capacities or with buried profiles did not sustain serious damage. Where horizontal color or textural bands beginning at depths of 3 feet occurred in quantity, the red pine overcame shoot moth attack. These bands are believed to increase the moisture-holding capacities of the soil series in which they occur.

Life Table Studies Show Important Natural Control Factors

In 1958 life table studies were begun in six plantations (five red pine and one Scotch pine) infested with the European pine shoot moth. The study areas are examined six times a year. At each examination the dead and living insects are counted and, where possible, cause of death is also recorded. By doing this in plantations that are lightly infested as well as those that are heavily infested, and in lightly and heavily infested portions of the same plantations, some insights into natural controlling mechanisms can be derived.

So far these studies reveal two periods in the shoot moth life cycle when significant natural mortality occurs. Mortality is always high in all plantations during the winter, regardless of the severity or mildness of the weather. The other period is during the early stages of larval feeding. Heavy mortality does not occur at this time in all plantations, however, and this fact helps to point up the

importance of this mortality: it characteristically occurs in those plantations and parts of plantations where the insect is not causing much damage. By contrast, mortality is not heavy in plantations and parts of plantations where the insect is at very damaging levels. This crucial early larval mortality in stands of vigorous, rapidly growing trees seems to be caused by either needle base tissue or bud tissue, the first two tissues the larvae feed on after they hatch. Attention is now being focused on this vulnerable period to learn more about the effects that the tree has on the insect and how these effects can be put to use to protect plantations from the insect.

Imported Parasite Successfully Established

European pine shoot moth populations tend to be about 10 times higher in Michigan and other areas of North America than in Europe where the insect is not a serious pest. One contributing factor to the better natural control experienced in Europe is the rich fauna of natural enemies which is lacking here. In an effort to ameliorate this situation, one species of parasitic wasp, *Orgilus obscurator,* was imported from Switzerland and released in Michigan in 1959. This shipment of 100 adults was released in the center of a 1-square-mile plantation of infested red pine. A year later, sampling at the release point showed that the parasite was successfully established. The spread outward from this point and the buildup of the parasite population will be investigated in coming years. Plans are also underway to introduce other European parasites of this insect.

POPLAR BORER—ADDITIONAL INFORMATION ACQUIRED

Research on aspen insects was centered on the poplar borer, *Saperda calcarata,* commonly found in most Lake States' aspen stands and a primary pest of trees above 3 inches in diameter. The impact of this borer cannot be described in exact monetary terms because of its many indirect effects and also the relative instability of the aspen market. Certainly the value of infested aspen logs destined for use as lumber, veneer, and other products requiring clear, sound wood is greatly reduced by the presence of the large larval tunnels. Other, perhaps more important, effects of the pest are: (1) infested trees are very subject to wind breakage, (2) abandoned tunnels serve as openings for the introduction of rots and decays, and (3) even unsuccessful attacks and barren egg niches are frequently centers of stain that render the wood unacceptable for use as high-quality pulp.

At present, no feasible control is known for the poplar borer. It is believed, however, that continuing biological and ecological investigations will reveal information that will serve as a background for the development of practical control methods. From the standpoint of prevention of attack, it is known that anything which reduces the stocking density of an aspen stand (even sanitation cuts) will increase the likelihood of severe poplar borer infestations.

FIGURE 30.—Poplar borer larvae of about the same age, magnified several times. *Left,* healthy larva; *Middle,* black, flaccid, disease-killed larva; *right,* contracted, dehydrated larva—death probably caused by insufficient moisture in rearing block.

An interesting possibility of biological control was discovered during a larval rearing study. About 200 specimens, which were being reared in small aspen blocks in the laboratory, died over a period of about 2 weeks. The cadavers were black, limp, and odoriferous. The cause of death is not known, but a virulent disease seems very likely. In a limited test, two healthy second-year larvae were placed in rearing blocks previously moistened with a crude suspension of diseased larval tissue in distilled water. The larvae died after about 7 weeks. Out of 15 control larvae, only one died, and it did not have the black, flaccid

appearance of the diseased larvae (fig. 30). No insect parasites or predators were observed during the study.

Apparently the physical requirements of young larvae include living wood. Young test larvae behaved normally for a week or two when placed in freshly cut rearing blocks. Then, in spite of periodic moistening of the blocks, the larvae died after a peculiar period of increased boring activity. Many of them girdled the entire block two or three times before they died. In nature, the larvae bore more slowly and usually in a vertical direction near the center of the stem. Mature larvae do not need fresh wood, since they construct normal pupal chambers even in dry aspen lumber.

Whether other species of wood are suitable for the poplar borer larvae is not known. Attempts to rear larvae in blocks of birch, maple, and oak were frustrated by the above-mentioned disease. Judging by initial boring activity, birch may be a suitable host for at least the mature larvae.

Field investigations to determine possible differences between infested and uninfested trees included a study of bark moisture content. The ratios between the weights of fresh and ovendry bark averaged about 1.8 (during August) for trees containing actively boring larvae. The bark of vigorous unattacked trees yielded a similar ratio. However, trees that had a number of unsuccessful attacks (old egg scars) but contained no living larvae yielded ratios of 2.0 or more. No obvious differences in d.b.h., growth rate, or crown size could be found between normal trees and those with a high bark-moisture content. It is tempting to speculate on whether some genetic variants may be resistant to poplar borer attack.

An attempt was made to evaluate three concentrated chemical extractives of aspen bark as possible food or oviposition attractants for the poplar borer. Since this was not a peak adult emergence year, no conclusive results were obtained. Further effort along this line is worthwhile because, considering the relatively low current value of aspen, chemical attractants would be one of the few economically feasible control methods.

ZIMMERMAN PINE MOTH—BIOLOGICAL STUDIES UNDERWAY

During the past few years, damage by the Zimmerman pine moth (*Dioryctria zimmermani*) has become more abundant in red pine and Scotch pine plantations in Michigan. To gather information necessary for formulating control procedures for this insect, a study of its population dynamics was started. A tiny wasplike parasite, *Hyssopus rhyacioniae,* appears to be a prevalent factor in mortality.

Work has also been started on the identification of the insects causing damage similar to that of the

FIGURE 31.—Forked or crooked stems caused by Zimmerman pine moth injury can result in degrade.

Zimmerman pine moth and frequently attributed to it. This insect apparently is capable of infesting both the trunk and tips of small pine trees, but in large, nearly mature red pine it infests only the tips (fig. 31). A closely related species, *Dioryctria cambiicola,* has also been found associated with Zimmerman

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pine moth tip damage in large red pine in Michigan and Minnesota. To determine the presence of other insects, more infested tips will be collected and identified.

Zimmerman pine moth attacks are frequently found in mechanical wounds, scars, or galls on pine. This suggests that the odor of the resin might attract the egg-laying adults. This hypothesis is being tested in the laboratory by subjecting test moths to various odors.

SURVEYS AND SURVEY METHODS

Color Photography in Aerial Surveys Shows Promise

The investigations started in 1957 to determine more efficient methods for detecting insect defoliation by observation from the air have been completed. In the course of the work other avenues of approach, especially color photography, became apparent, and research is now beginning on them. The Station has been conducting this work in cooperation with the aerial survey team from the Beltsville, Md. Forest Insect Laboratory.

Results of the ocular phase of the study show that trained observers can consistently detect two degrees of defoliation even at altitudes of 1,000 feet: severe current feeding in addition to previous years' heavy defoliation, and moderate to heavy feeding. Light defoliation is difficult to identify, however; consequently light and no visible defoliation have been lumped into one category.

In general, trained observers are more consistent in their evaluation at an altitude of 500 feet than at 1,000 feet. Other factors under study in addition to altitudes include the use of a haze filter and trained and untrained observers. When analysis of all the variables has been completed the best combination will be determined.

Results of investigations with color photography as a tool for surveying forest insect infestations are very promising. Four degrees of spruce budworm

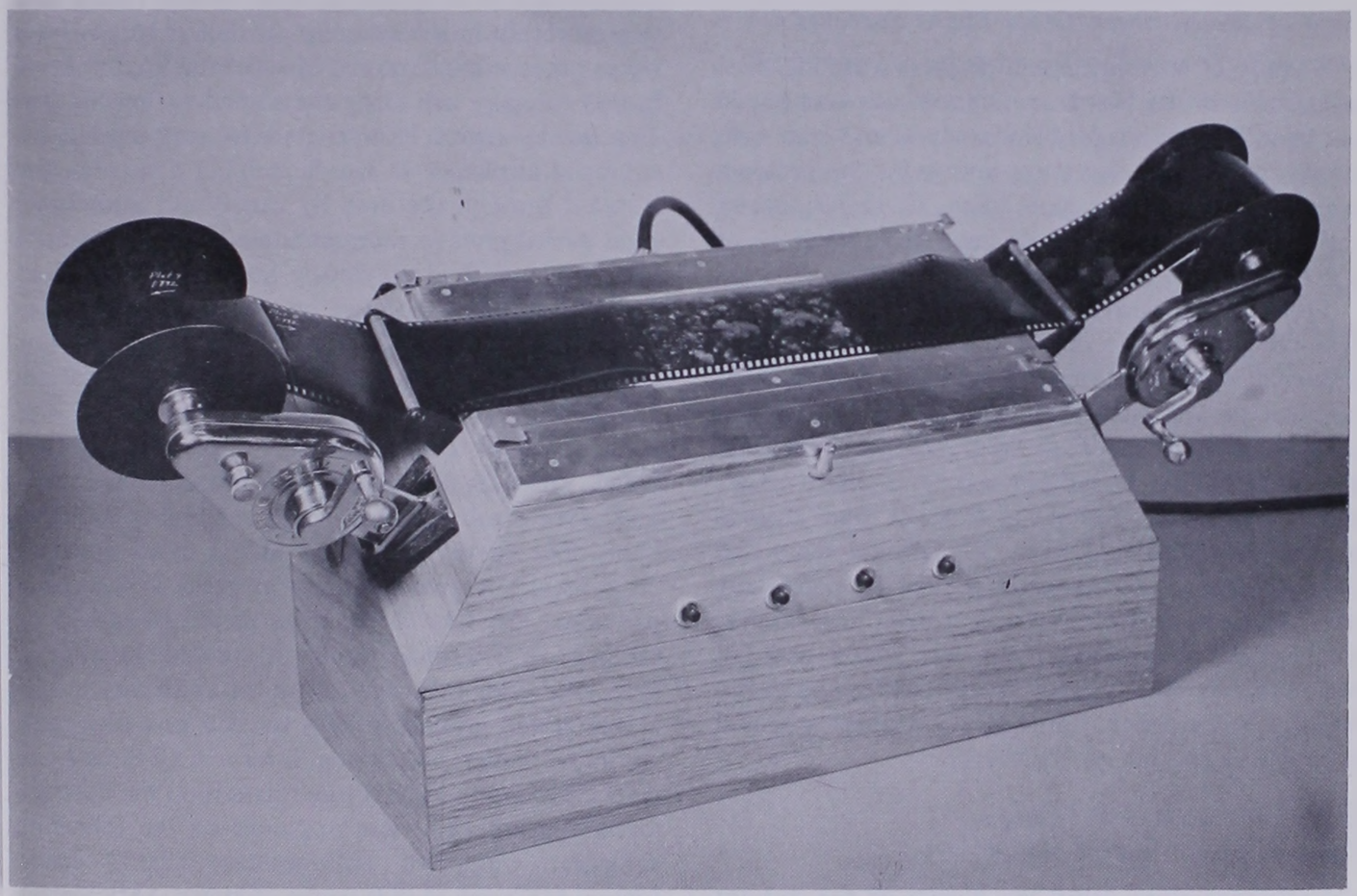

FIGURE 32.—Special instrument used with stereoscope to view 70 mm. color films of spruce budworm defoliation.

defoliation were photographed at several scales, using super Anscochrome film in a special camera fitted with a high-speed lens. The 70 mm. photos were then viewed stereoscopically by means of a special instrument (fig. 32).

The five observers' results agreed very closely. However, at the scale of 1:1980, defoliation was generally classified from the photos as being lighter than it actually was. Heavy and moderate defoliation could not be easily separated. Defoliation interpreted as light from the air often was found to be moderate when checked by a ground survey. This indicates a need for further training of interpreters and larger scale photography. With the largest scale tried—1:792—all four defoliation categories are clearly distinguished. Whether a scale between this and 1:1980 will give satisfactory results is not yet known.

Color photography, begun in 1957, will be continued until the outbreak collapses; this will provide a chronological picture of the damage following budworm feeding.

Pests of the Northern Great Plains Surveyed

A study of the insects and diseases affecting trees and shrubs in the Northern Great Plains was begun this year, first with a problem analysis and later with a field survey. The literature review for the problem analysis revealed that more than 50 insect species and nearly as many diseases have been injurious at one time or another since the 1880's.

The survey covered all of North Dakota, that part of South Dakota east of the Missouri River, and the plains of western Minnesota, but was largely concentrated in the shelterbelt zone. Observations and collections were made at 325 locations, covering 285 shelterbelts, 30 natural stands, 5 urban areas, and 5 nurseries. About 150 insect and disease species were collected from 33 different trees and shrubs. Some of the more important or potentially serious insect associations were: lace bugs on bur oak, aphids on American elm, leaf rollers and fall webworms on chokecherry, blister beetles and grasshoppers on caragana, hornworms on green ash, and several gall species on hackberry.

Evaluation Surveys Continued To Determine Control Needs

Each year since 1955 the course of the current spruce budworm epidemic in the extensive spruce-fir stands of the Superior National Forest and adjacent lands has been aerially surveyed and mapped. This information is used by the Supervisor and his staff to determine where blocks of timber must be harvested or treated with insecticides and protected from defoliation until they can be cut. The 1960 survey revealed that of the 1,267,000 acres of spruce-fir type flown, defoliation categories were: severe 96,000 acres, moderate to heavy 650,000 acres, light to nonvisible 521,000 acres. This is an increase over 1959 in the moderate to severe classes and a decrease in the light to nonvisible. The Superior National Forest has proposed control in 1961 on blocks of nearly 67,000 acres of spruce-fir timber, all located in the moderate to severe area. Biological evaluations of the proposed spray units have already been started; this work will continue up to the time of spraying. Data are being collected on numbers of overwintering larvae, amount of parasitism, overwintering losses, etc. The control, if applied, would be for the purpose of keeping the trees alive until they can be harvested.

Until this year the magnitude of top killing and tree mortality in the severely defoliated spruce budworm areas was unknown. Most of the 96,000 acres in this category are along the Canadian border (fig. 33) where travel is restricted to canoe or float-equipped airplanes. In late September a survey crew traveled through the area by canoe and established eight paired plots in representative stands. To reduce bias, the route had previously been type-mapped by air, and the plots located on the maps. The plots varied from 1/7 to 1/3 acre, depending on tree density. The goal was to tally from 80 to 100 balsam fir and white spruce trees on each plot. A tree with a dead top of 2 or more feet was tallied as top killed. This was determined by a binocular examination. Tree death was verified by examining the cambium. The survey shows top killing of as much as 78 percent and tree mortality as great as 2.4 cords per acre. The fate of the trees in the plots will be followed to determine trends in the deterioration of spruce-fir after a spruce budworm epidemic.

Aerial and ground surveys showed jack-pine budworm defoliation on national forests in all three Lake States. Moderate to heavy defoliation on the national forests during 1960 was apparent on the following acreages: Chippewa (Minnesota) 15,000 acres, Upper Michigan 4,900 acres, Ottawa (Michigan) 2,500 acres, Chequamegon (Wisconsin) 8,300 acres.

Egg counts on these acreages indicate that populations may also be high in 1961. Further biological checks are needed next spring to determine whether control action is needed.

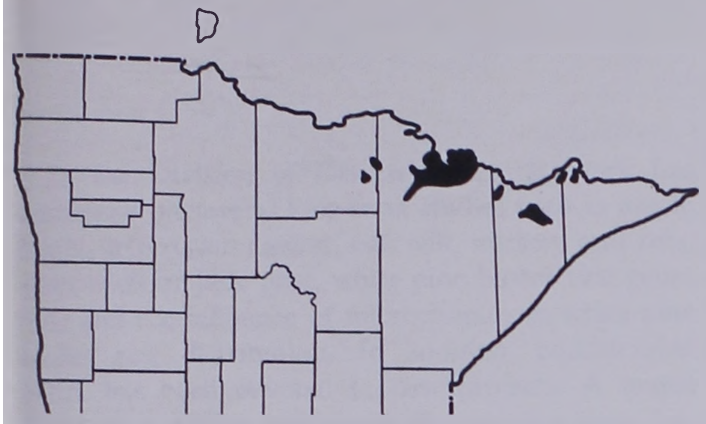

FIGURE 33.—Areas in Minnesota where top killing and tree mortality of balsam fir and white spruce are occurring after repeated defoliation by the spruce budworm.

Adult spittlebug sweep surveys made by the Station entomologists in August and September revealed that about 3,400 acres of red pine plantations on the national forests in Wisconsin and Michigan may need treatment in 1961. Nearly 3,000 acres are on the Nicolet in Wisconsin and the rest is divided among the four other national forests of the two States.

Technical Assistance Provided For Control Projects

The Station provides technical assistance on control operations to the national forests and to other Federal, State, and private agencies when requested.

In 1960 the Superior National Forest sprayed about 24,000 acres of spruce fir to control the spruce budworm. In addition to the usual technical assistance, the Station made biological evaluations both before and after the spraying. Post-control surveys indicated satisfactory results.

Late spring larval checks of jack-pine budworm populations on the Chippewa National Forest substantiated the survey results obtained the previous fall. The numerous larvae and the small degree of parasitism indicated that heavy defoliation would occur if the stands were left unsprayed. As a result DDT was aerially applied to 1,000 acres. Control was very good.

Natural control factors reduced spittlebug nymphal populations in some areas, such as certain plantations on the Chequamegon and Nicolet National Forests. However, 2,923 acres had a sufficiently high population to warrant treatment. Small acreages were also sprayed for control of the red-headed pine sawfly.

Work has progressed very well on a rapid method of determining population levels of the European pine shoot moth. A relationship has been found between the percent of trees infested and the number of insects per tree. The "whole-tree index" method gives results for infestations up to six insects per tree. Higher population levels require the "leader index method." These surveys can be used during the spring or fall, but the relationships are not the same for both seasons.

FOREST DISEASES

RALPH L. ANDERSON, *Division Chief*

In the Division of Disease Research, work has continued on several long-term studies such as maple blight, hypoxylon canker, oak wilt, nursery root rots, stem rusts of jack pine, white pine blister rust genetics, and the influence of microclimate on white pine blister rust distribution. In addition, considerable effort has been devoted to new projects. A major study of northern hardwood diseases has been initiated with emphasis on the maple dieback problem and on defect in hard maple. Other new studies include an appraisal of problems on the northern Great Plains and an evaluation of antibiotics for controlling conifer rust diseases.

A greatly facilitating factor in the Division's program is the cooperation of several agencies. Without their assistance on many of the studies, the scope of the work would be much narrower.

Another favorable factor is the increased ability of the Station staff to deal with disease problems. Two staff members took several graduate-level courses in pathology this year at the University of Minnesota, which added to their technical knowledge. In addition, a position in the Division, vacant for several months, was filled by Darroll Skilling. Mr. Skilling had 2 years' previous experience with the Disease Research Division and then 4 years in forest management research at the Wausau, Wis., field office, where many of his studies pertained to disease problems. In June Dr. Kenneth Kessler, assigned to the study of diseases in northern hardwoods, was transferred from the St. Paul office to the new Genetics Laboratory at Rhinelander, Wis. This places him closer to the problems he is working on and provides him with improved laboratory facilities.

Maple Dieback Problem Under Investigation

Foresters are alarmed by the appearance of dieback symptoms on hard maple in many areas throughout the Lake States Region. This is a widespread problem that is also causing considerable concern in the eastern States and eastern Canada. The possibility of serious damage to one of our most valuable tree species seemed sufficient to warrant intensive study. This was initiated last winter.

A study to determine whether deterioration of root systems is causing dieback has been started. Root-washing and root-sampling techniques are being used to examine the root systems of healthy and dieback trees. Preliminary findings indicate that, in general, dieback trees have more rootlet mortality. Efforts are being made to learn if a fungus is responsible.

The role of possible stem pathogens which attack and kill twigs and branches directly is also being investigated. So far no evidence of such pathogens has been found except for one tree killed by the sapstreak disease (fig. 34). This disease is caused

FIGURE 34.—Section from a hard maple affected by the sapstreak disease. This is the first and only maple so far known to have this disease in the Lake States.

by the fungus *Ceratocystis coerulescens*, a close relative of those causing oak wilt and Dutch elm disease. The disease has been present in local areas in the southern Appalachians for several years, but has not previously been found in the Lake States.During the summer of 1960 a number of additional suspect trees

were examined in Michigan and Wisconsin, but none proved to have the disease. Efforts to determine the extent and prevalence of this disease will be continued in 1961.

Causes of Defect in Maple Also Studied

Identification of the organisms present in various defects of hard maple is the subject of another study (fig. 35). Most of the materials were already at hand. These consisted of dissected sample trees with defects used by the Division of Forest Utilization in their timber quality study. Photographs and diagrams of the dissections as well as of the external appearance of the defects were also available. This past summer, isolates were obtained from any representative types of defect, and these are now being identified. The photographs and diagrams provide an unusual opportunity to relate the identified fungi to well-described types of defect.

FIGURE 35.—Dr. Kenneth J. Kessler identifying fungi that cause hard maple defects in the new laboratory at Rhinelander.

Maple Blight Studies Indicate Insects Are a Major Factor

Detection and appraisal surveys have shown no spread or intensification of maple blight since the occurrence of alarming damage in 1957. This, plus the fact that no virulent primary pathogen was found, has alleviated the extreme alarm with which this disease was viewed by foresters and pathologists. The several cooperative studies of the problem, partly financed by the Northern Hardwood and Pine Manufacturers Association, the Maple Flooring Manufacturers Association, and the Birch Club, have been largely concluded.

Several of these studies for various reasons included defoliation experiments. The results now available from these studies are in substantial agreement. They all indicate that hard maple is much more susceptible to severe injury from defoliation than was previously believed. Most investigators now think that the outbreak of defoliating insects preceding the onset of blight symptoms was a key factor in causing the damage.

Some of the studies that were initiated with the cooperative funds needed continued effort to be carried to a conclusion. The Michigan College of Mining and Technology undertook a defoliation study with college funds; and the University of Wisconsin is carrying through with State funds on those pathogen and insect studies that needed additional attention.

The Station is continuing its study of the effects of defoliation and reduced soil moisture on large maples with Forest Service funds (fig. 36). Available moisture is controlled by use of rainfall intercepts to reduce soil moisture to various levels below normal, and by irrigation to provide levels above normal. The study is designed to evaluate both the separate and the combined effects of defoliation and drought.

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FIGURE 36.—Equipment used in a maple blight study to determine the effects of defoliation and drought.

Oak Wilt Study at Turning Point

The oak wilt survey conducted annually since 1955 to determine the rate of local and long-distance spread of this disease has now been concluded. Only the sample areas in Adams County, Wis., were surveyed this year. They showed that both local and long-distance spread were greater than in any other year since 1955. The disease on all of the permanent study areas used has intensified to the point where their utility for obtaining further information of this kind is reduced.

We now have a substantial body of information on rate of spread for a 5-year period. A summary is being prepared for publication. There are other aspects of the oak wilt intensification problem that need to be surveyed to provide the best possible basis for evaluating the future impact of this disease on the region's oak forests. At present plans are indefinite as to when and how this will be done.

IBM Analysis of Hypoxylon Canker Data in Progress

Hypoxylon canker investigations are continuing, with emphasis on a comprehensive analysis of the large body of data collected during the past several years. Most of these data have been transferred to IBM punchcards and some preliminary analyses made. These are being used in charting the course for future detailed analyses to extract all significant information from the data. The major portion of this task will probably be accomplished within a year. The results should provide not only practical information on this problem, but also the basis for designing any future studies of the hypoxylon canker problem.

Work is being continued on current field studies. This involves reexamining permanent aspen plots at periodic intervals to evaluate trends in canker populations and tree mortality.

Microclimatic Factors in Blister Rust Distribution Suggest Aids to Control

As indicated in previous reports, research on the influence of microclimate on white pine blister rust distribution has permitted development of aids to blister rust control. In southern Wisconsin microclimate determines where serious rust infection will be found. Areas with serious infection are narrow valleys, kettle holes, the bases of slopes, and other places into which cool air will drain and accumulate at night. Areas continually shaded, such as small openings in the forest canopy, and areas with high elevations, especially above 1200 feet, also favor rust infection. In other situations the potential for rust damage is very low. Through use of this knowledge, considerable adjustments and economies have already been effected by elimination of ribes eradication in areas where rust does not present a serious hazard.

Considerable progress has been made on studies of the environmental requirements of the rust and on temperature and moisture distribution and related air movements in the forest. This work has suggested a number of possible approaches to improving rust control practices in the high-rust-hazard northern areas where the general climate is particularly favorable for the disease.

One of these is to maintain an overstory above young white pine. This reduces infection by creating less favorable moisture conditions for the rust under the canopy. It is believed that such a canopy also reduces weevil injury. Observations to date suggest that in making release cuttings in such overstories no openings should be made that are larger than a single tree crown, and these only in overstories of pole-size and larger trees.

Another suggested modification in high-rust-hazard areas is to eradicate ribes across all open areas adjacent to the pine and 100 feet into the woods, no matter how distant the wooded area; also eradicate a 100-foot-wide strip into wooded swamps. A barrier strip (windbreak) between pine and open areas may eliminate need for some of the very long-distance eradication suggested above.

These ideas for improvements in control practices are based on a better knowledge of air circulation during periods favorable for infection and of the factors influencing the circulation. Blister Rust Control personnel are taking part in testing these possibilities.

Antibiotics Tested to Control Rust Diseases

The use of systemic fungicides (antibiotics) to control rust diseases is the major recent development in forest disease control. Outstanding success has been achieved in the western States in controlling blister rust on western white pine with antibiotics. However, effective application of this control method to the rust problems of this region still requires intensive testing and evaluation.

During the past few years the Station has participated to a very limited extent in tests, most of them in collaboration with Blister Rust Control personnel. Results to date are inconclusive and seem to indicate a more complex situation than is found in western white pine. In some cases evidence of potential effectiveness has been found, but many tests have given no control and some have injured the treated trees. Apparently much of the problem involves selection of a suitable carrier oil and possibly time of application. Most of the tests for control of blister rust on eastern white pine have been with cycloheximide (Acti-dione). Although the Station is not staffed to give this problem the attention it deserves, some new studies were established this past year. Some of these involve Acti-dione, with more attention given to the problem of suitable carrier oils. Also under study is another promising systemic fungicide, phytoactin. These tests are, as yet, too new for evaluation.

At the Eveleth Nursery a study was established to test the effectiveness of systemic fungicides in controlling infection by stem rusts of jack pine nursery stock.

Methyl Bromide Still the Best Control for Nursery Root Rots

During the past 2 years the Station has not done any intensive research on control of nursery root rots. The methyl bromide treatment developed a few years ago for white pine root rot at the Chittenden Nursery in Michigan is now standard practice and is proving very effective. Some nurseries in Minnesota are now testing this method on a pilot scale for control of black spruce root rot. The results to date

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show promise. Station pathologists are following this work closely. As new materials become available and staff time permits, additional research will be done on this problem.

Northern Great Plains Disease Survey Points to Major Problems

During the past summer a relatively intensive survey was made of insect and disease problems of the northern Great Plains. Of the diseases present, box-elder blight is the most serious. Available evidence indicates a strong probability that it is caused by 2,4-D (more information on this is given in the Forest Management section). The serious dieback of elms noted a few years ago in southeastern South Dakota does not appear to be intensifying. Several foliage diseases of hardwoods and damping-off of ponderosa pine are recognized as important nursery problems, and diebacks of hardwoods are important in some shelterbelts.

LIST OF PUBLICATIONS, 1960

LAKE STATES FOREST EXPERIMENT STATION

General Forestry

Dickerman, M. B. ACHIEVING FULL USE OF FOREST LAND. U. S. Forest Serv., Lake States Forest Expt. Sta. (no series), 9 pp. (Processed.)

(Discusses the many and various demands made on forested land and the need to manage it to obtain the greatest possible benefits.)

Dickerman, M. B. HISTORY AND PROBLEMS OF TREE PLANTING IN THE NORTHERN PLAINS. U. S. Forest Serv., Lake States Forest Expt. Sta. (no series), 9 pp. (Processed.)

(Reviews tree planting efforts from pioneer days to the present. Discusses the most significant research findings, and points out some of the more obvious research needs.)

Lake States Forest Experiment Station. 1959 ANNUAL REPORT. 71 pp., illus. (Processed.)

(Examines the forest protection situation in the Lake States and its related research needs. Describes some of the current research underway on forest insects, diseases, and fire, and touches on future plans.)

McCulley, Robert D. REVIEW OF "LOBLOLLY PINE; ITS USE, ECOLOGY, REGENERATION, PROTECTION, GROWTH, AND MANAGEMENT" BY W. G. WAHLENBERG; 603 pp., illus., Durham, N. C. Jour. Forestry 58: 977-979.

Rudolf, Paul O. REVIEW OF "DIE EICHEN" (THE OAKS) BY JOACHIM KRAHL-URBAN; 288 pp., 110 illus.; Hamburg and Berlin; 1959. Forest Sci. 6: 252.

Weitzman, Sidney. SHOW-ME TOUR FOR WORLD FORESTERS. Conserv. Volunteer 24(138): 39-43, illus.

(Describes tour of forestry activities in Minnesota by members of World Forestry Congress.)

Regeneration, Stand Improvement, and Harvest Cuttings

* Arend, John L., and Roe, Eugene I. HOW TO RELEASE CONIFERS IN THE LAKE STATES WITH CHEMICALS. U. S. Forest Serv. (no series), 31 pp., illus. (Processed.)

(A description of the present status of the different chemical methods used for release of natural and planted pines and other conifers from undesirable hardwood trees and brush. The information presented is based on research results obtained by the authors in Lower Michigan and northern Minnesota.)

* Batzer, H. O. TWO CASES OF WIND DAMAGE TO BALSAM FIR AFTER CUTTING. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 590, 2 pp. (Processed.)

(Losses are given for storms of known wind velocity in two areas of partial cut and commercial clear cut balsam fir stands; one area was near International Falls and the other near Grand Marais, Minn.)

* Benzie, John W. VIABILITY OF BALSAM FIR SEED DEPENDS ON AGE OF TREE. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 591, 2 pp., illus. (Processed.)

(Seed viability generally decreased with tree age after reaching a peak of 68-percent potential germination for a tree 41 years of age. Actual germination of seed from the oldest tree tested, 155 years, was 3 percent and potential germination was 10 percent.)

* Buckman, Robert E. HIGH GROWTH RATE MAINTAINED BY 140-YEAR-OLD RED PINE. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 587, 2 pp. (Processed.)

(Over a 33-year period a red pine stand has grown an average of about 500 board feet per acre. During the same period, about 22,000 board feet per acre have been removed as thinnings, and about 10,000 board feet remain as growing stock.)

Buckman, Robert E., and Zasada, Z. A. MINNESOTA'S NATIVE PINE PAYS OFF. Conserv. Volunteer 23 (135): 7-10, illus.

(Growth rates from four long-term red pine experiments are described to show the potential of Minnesota's forest land.)

* Buckman, Robert E., and Zasada, Z. A. FIVE-YEAR RESULTS OF A GROWING-STOCK DENSITY STUDY IN 85-YEAR-OLD WHITE PINE. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 589, 2 pp. (Processed.)

(A white pine stand, divided into 5 compartments, was thinned to 80, 100, 120, and 140 square feet of basal area per acre. Five years later the 100-, 120-, and 140-square-foot levels had increased by over 4,000 board feet per acre. The 80-square-foot treatment grew 3,300 board feet in the same period.)

* Available for distribution.

* Church, Thomas W. INITIAL EFFECT OF RESIDUAL STOCKING LEVELS ON BASAL AREA PRODUCTION IN NORTHERN HARDWOOD STANDS. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 581, 2 pp. (Processed.)

(A residual stocking level of 30 square feet per acre in basal area resulted in less gross production than the three higher levels of 50, 70, and 90. There was no significant difference between the three higher levels during the first 5 years after cutting.)

* Church, Thomas W., Jr. RESIDUAL STAND DENSITY AND THE EARLY DEVELOPMENT OF NORTHERN HARDWOOD REPRODUCTION IN UPPER MICHIGAN. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 593; 2 pp. (Processed.)

(Mature northern hardwood stands were cut to residual basal area densities of 30, 50, 70, and 90 square feet per acre. Observations made 2 and 5 years after logging showed that residual stand density had no significant effect upon the number of seedlings present or the number of quadrats stocked with sugar maple. However, stand density did influence the percentage of quadrats stocked with yellow birch. Stand densities of 30 and 50 square feet per acre gave a greater increase in the percentage of quadrats stocked with birch than did denser overstories.)

* Della-Bianca, Lino, and Dils, Robert E. SOME EFFECTS OF STAND DENSITY IN A RED PINE PLANTATION ON SOIL MOISTURE, SOIL TEMPERATURE, AND RADIAL GROWTH. Jour. Forestry 58: 373-377, illus.

(Decreasing stand basal area rendered an initial supply of soil moisture available over a given period of time for the remaining trees. This temporary increase in soil moisture in the A horizon contributed to increased growth in thinned stands.)

Gammon, A. D., Rudolph, V. J., and Arend, J. L. REGENERATION FOLLOWING CLEARCUTTING OF OAK DURING A SEED YEAR. Jour. Forestry 58: 711-715, illus.

(Data on the reproduction following the clearcutting of an excellent 45-acre tract of oak sawtimber were collected periodically for 7 years after logging. Adequate reproduction developed to furnish a fully stocked new stand. However, the species composition of the new stand had little resemblance to that of the previous stand. Adequate oak reproduction was not obtained by clearcutting during a bumper seed year.)

* Godman, Richard M., and Krefting, Laurits W. FACTORS IMPORTANT TO YELLOW BIRCH ESTABLISHMENT IN UPPER MICHIGAN. Ecol. 41: 18-28, illus.

(Discusses regional differences of factors affecting establishment and early growth. Evaluates seed production, seedbed condition, competition, precipitation and temperatures, frost, shade requirements, and injury by animals in a seed-tree cutting in the hemlock-yellow birch cover type. Scarification to expose mineral soil on 50 percent or more of the area in conjunction with recommended silvicultural practice is most favorable for seedling development.)

* Roe, Eugene I. AUGUST-COLLECTED CONES YIELD POOR RED PINE SEED. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 575, 2 pp. (Processed.)

(Red pine cones collected in the third week of August produced one-fifth less seed than cones collected in September. Moreover, the seed showed only 54-percent germination compared to 85 percent for September seed.)

* Roe, Eugene I. RESTORING SWAMP CONIFERS ON BRUSHY LOWLAND REQUIRES ADEQUATE BRUSH CONTROL, LARGE STOCK, AND CAREFUL PLANTING. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 584, 2 pp. (Processed.)

(Tests in northern Minnesota indicate that plantings of black spruce and tamarack on brushy lowland have a reasonable chance of success if the following precautions are taken: (1) Spray the brush with herbicides; (2) use transplant stock and plant no later than the spring following spraying; (3) plant on the hummocks and only when the surface is not frozen; (4) avoid concentrations of dense grass; (5) leave an unplanted buffer strip as hare insurance.)

* Rudolf, Paul O. 1959 FOREST SEED CROP GENERALLY POOR IN THE LAKE STATES. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 574, 2 pp. (Processed.)

(Seed crops for the principal forest tree species are listed in percentage of a full crop for northern Minnesota, northeastern Wisconsin, central Upper Michigan, Lower Michigan, and north central North Dakota. Although some species produced bumper crops in Wisconsin, most crops in most localities varied from failure to fair or good.)

* Scholz, Harold F. PRESENT STATUS OF OAK MANAGEMENT IN WISCONSIN. Iowa State Jour. Sci. 34: 649-660, illus.

(Summarizes briefly what has been learned about oak management in Wisconsin during the past decade. The role of improvement, shelterwood, and clear cuttings is discussed, and the need for "reinforcing" natural regeneration of northern red oak with cultural aids such as soil scarification, direct seeding, and planting of nursery stock also is discussed.)

* Scholz, Harold F., and Trenk, Fred B. TIMBER YIELDS, WOOD INCREMENT, AND COMPOSITION OF REGENERATION IN A MANAGED HARDWOOD FOREST ON MORAINAL SOILS. Wis. Acad. Sci., Arts, and Letters Trans. (89th Ann. Meeting), pp. 11-29, illus.

(Even though 45,000 board feet of saw logs and 208 cords of fuelwood were removed in the past 10 years, good forest management practices have improved both

the volume and quality of the mixed-oak stands on the Dundee Timber Harvest Forest in east central Wisconsin. This was accomplished by eliminating as many poor trees as possible during each of six harvests and by cutting less wood than was added by growth.)

Skilling, Darroll D. A TRACTOR-MOUNTED LADDER FOR TREE-CROWN STUDIES. Food and Agr. Organ. of the United Nations, Forestry Equip. Note A.20.60, 2 pp., illus. *Also* U. S. Forest Serv. Tree Planters' Notes 43: 9-10, illus.

(Describes an aerial ladder mounted on a crawler tractor suitable for tree-crown studies up to 45 feet. The principal advantages of this device are its ability to travel rough forest terrain and its reasonable price (total cost $320 plus tractor.))

Stoeckeler, Joseph H., and Arneman, Harold F. FERTILIZERS IN FORESTRY. Adv. in Agron. 12: 127-195, illus.

(Gives a comprehensive review of literature on the use of fertilizers in forest nurseries and in natural and planted stands, with considerable original data on the effects of fertilizers. pH amendment, and mycorrhizal inoculation in forest nurseries.)

* Strothmann, R. O., and Conover, D. F. A FIELD TEST OF THE BAKER SEED TOOL IN NORTHEASTERN MINNESOTA. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 579, 2 pp. (Processed.)

(The Baker Seed Tool was tested on six areas on the Superior National Forest, using red pine and jack pine seed. Although none of the treatments could be considered successful, the study showed spring seeding to be superior to fall seeding, and screening against rodents to be superior to leaving the spots unscreened.)

Trenk, F. B., and Scholz, H. F. THE WAUSAUKEE TIMBER HARVEST FOREST. Wis. Conserv. Bul. 25 (3): 28-31, illus.

(Describes the 11-year results of managing 32 acres of well-stocked, 65- to 70-year-old mixed white and red pine in northeastern Wisconsin. From 1948 to 1959 the total volume increased from 183,000 to 268,000 board feet, net log scale, despite the fact that 40,000 board feet of logs and 224 cords of boltwood, worth $3,571, were removed from the tract during the same period. Suppressed, intermediate, and head-dominant pine and competing hardwoods (scrub oak, aspen, and red maple) have provided the bulk of the cut.)

* Watt, Richard F. A TEST OF WOOD FIBER PADS AS A SEEDBED MULCH. U. S. Forest Serv. Tree Planters' Notes 41: 5-7.

(Wood fiber pads were used as a mulch in seed flats in a greenhouse test with jack and red pines and black and white spruces. Various thicknesses of pads were used, but even the thinnest one, which would be difficult to apply on large beds in a nursery because of low tensile strength, was penetrated by the germinating seeds with difficulty.)

Tree Improvement

Jensen, Raymond A., Schantz-Hansen, T., and Rudolf, Paul O. A STUDY OF JACK PINE SEED SOURCE IN THE LAKE STATES. Univ. Minn. School of Forestry Note 88, 2 pp., illus. (Processed.)

(Included is a brief description of the study involving 29 Lake States sources set out in 17 plantations. Fifth-year average results in height development are given for six Minnesota plantations.)

Kozlowski, Theodore T., and Cooley, John H. NATURAL ROOT GRAFTING IN FOREST TREES. Univ. Wis. Forestry Res. Note 56, 1 p. (Processed.)

(Root-excavation studies conducted at the Argonne Experimental Forest show that intraspecific grafting between adjacent trees was common for sugar maple, red maple, yellow birch, paper birch, white pine, red pine, balsam fir, eastern hemlock, and northern white-cedar. The large amount of this type of root grafting raises questions about its physiological and silvicultural implications.)

* Lake States Forest Tree Improvement Conference. PROCEEDINGS OF THE FOURTH LAKE STATES FOREST TREE IMPROVEMENT CONFERENCE, OCTOBER 6 AND 7, 1959. U. S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 81, 60 pp., illus. (Processed.)

(Includes a "short course" in forest genetics, current tree improvement activities in the region, reports of special subcommittees, and other activities of the Lake States Forest Tree Improvement Committee.)

* Larson, Philip R. GIBBERELLIC ACID-INDUCED GROWTH OF DORMANT HARDWOOD CUTTINGS. Forest Sci. 6: 232-239.

(Gibberellic acid applied to dormant cuttings of a number of hardwood species induced preseasonal growth and development of the apical buds.)

* Larson, Phillip R. A PHYSIOLOGICAL CONSIDERATION OF THE SPRINGWOOD-SUMMERWOOD TRANSITION IN RED PINE. Forest Sci. 6: 110-122, illus.

(The transition from springwood to summerwood has been related to the cessation of activity of the terminal meristem. On the basis of experimental treatments involving debudding, daylength changes, and exogenous growth regulator applications, it was proposed that springwood formation results from high auxin activity, and the transition to summerwood occurs when auxin production decreases.)

* Nienstaedt, Hans. THE ECOTYPE CONCEPT AND FOREST TREE GENETICS. *In* Fourth Lake States Forest Tree Improvement Conf. Proc. U. S. Forest

Serv., Lake States Forest Expt. Sta., Sta. Paper 81: 14-25. (Processed.)

(Briefly discusses the objectives of studies of racial variation and methods of study. The patterns of variation within a native species in terms of ecotypes and clines are discussed.)

* Rudolf, Paul O. CURRENT FOREST TREE IMPROVEMENT RESEARCH IN THE LAKE STATES. *In* Fourth Lake States Forest Tree Improvement Conf. Proc. U. S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 81: 46-47. (Processed.)

(Brief summary of current activities of 70 research workers in 11 research agencies conducting some 113 formal forest tree improvement studies in the Lake States.)

Soils and Water

* Bay, Roger R. SOIL FREEZING OBSERVATIONS AFTER CHANGES IN FOREST COVER. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 576, 2 pp. (Processed.)

(Two years' observations indicate that concrete frost penetrates deeper and remains longer in the spring under a 20-year-old red pine plantation than under an adjacent area of aspen-brush. Variations in type and depth of the humus and the depth of the snowpack help explain the differences in frost penetration.)

* Curtis, Willie R. AN AUTOMATIC TRIGGER DEVICE FOR USE ON FW-1 WATER LEVEL RECORDERS. Jour. Forestry 58: 819-821, illus.

(Explains construction and operation of a time-saving trigger device used in conjunction with water-level recording on ephemeral streams. During no-flow periods the clock is kept from running by application of back pressure. When flow occurs, movement of float activates release mechanism and clock begins to run.)

* Curtis, Willie R. MOISTURE STORAGE BY LEAF LITTER. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 577, 2 pp. (Processed.)

(Galvanized tanks were placed under boxes that contained 2 to 3 inches of hardwood or pine litter. The rain that filtered through the litter was measured by weighing the tanks. Both kinds of litter held about the same amount of rainfall: 34.2 percent for hardwoods; 33.2 percent for pine. The amount retained varied from 93.7 percent for small rains to 11 percent for rains greater than 1 inch.)

Sartz, Richard S. FORESTS AND EROSION IN THE DRIFTLESS AREA. Wis. Conserv. Bul. 25(3): 21-24, illus.

(Explains how geologic erosion shaped the land forms of the Driftless Area and how man has triggered a new cycle of erosion through overdevelopment of the land for agriculture. A study of wooded watersheds showed no accelerated erosion.)

* Stoeckeler, J. H., and Curtis, Willie R. SOIL MOISTURE REGIME IN SOUTHWESTERN WISCONSIN AS AFFECTED BY ASPECT AND FOREST TYPE. Jour. Forestry 58: 892-896, illus.

(Gives results of soil moisture on a transect across a valley, from ridge to ridge, showing markedly better moisture conditions on north- versus south-facing slopes. Tree growth in pine plantations was 3.5 times better than in oak in south-facing slopes.)

* Stoeckeler, Joseph H., and Voskuil, Glenn J. WATER TEMPERATURE REDUCTION IN SHORTENED SPRING CHANNELS OF SOUTHWESTERN WISCONSIN TROUT STREAMS. Amer. Fisheries Soc. Trans. 88: 286-288, illus. 1959.

(Late afternoon summer water temperatures at the mouth of a spring channel on a trout stream near La Crosse in southwestern Wisconsin were reduced by 10° to 11° F. by shortening the channel by 67 percent and routing the water through a willow-shaded location.)

* Stoeckeler, J. H., and Weitzman, Sidney. INFILTRATION RATES IN FROZEN SOILS IN NORTHERN MINNESOTA. Soil Sci. Soc. Amer. Proc. 24: 137-139.

(Concretely frozen silt loam soils showed 0.09 inch of infiltration per hour, while sands of similar frost type showed 0.47 inch. A porous-concrete frost type was found in loamy sands; in these soils infiltration amounts were 2.19 inches for the porous-concrete frost, 3.97 inches in partly frozen soils, and 13.22 inches in unfrozen soils.)

Striffler, W. D. FORESTS HELP WATER SUPPLY. Mich. Farmer 233(4): 52-53, illus.

(Of Michigan's annual precipitation, 15 to 30 percent occurs as snow. Water received as snow forms a major portion of the water available for recharge to streams and ground water. The influence of various major forest types upon the accumulation and melt of snow and its significance are discussed.)

* Striffler, W. D. STREAMBANK STABILIZATION IN MICHIGAN—A SURVEY. U. S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 84, 14 pp., illus. (Processed.)

(A survey of 113 untreated and 115 treated streambanks in four Michigan watersheds demonstrates the stabilizing influence of rock riprap and vegetation upon erosion from streambanks.)

Forest Insects

* Batzer, Harold O. MINED BUDS, A HIBERNATION SITE FOR SPRUCE BUDWORM. Jour. Econ. Ent. 53: 684-685, illus.

(Hollowed-out vegetative buds of balsam fir caused by early season feeding were found to be used by spruce budworm larvae for hibernation sites in areas where balsam had not yet produced staminate flowers. These buds bear a striking resemblance to the empty cup-like staminate flower bracts found on mature balsam, which are so favorable for overwintering sites.)

* Drooz, A. T. THE LARCH SAWFLY: ITS BIOLOGY AND CONTROL. U. S. Dept. Agr. Tech. Bul. 1212, 52 pp., illus.

(A full account of the life history and habits of an important insect attacking tamarack. Natural control factors and direct control are discussed in detail.)

* Ewan, Herbert G. THE POPLAR BORER IN RELATION TO ASPEN STOCKING. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 580, 2 pp., illus. (Processed.)

(A discussion of the trends in infestation on 145 1/10-acre plots in aspen stands of varied stocking levels.)

Flink, Paul R., and Miller, William E. PLANTATION ENEMY NO. 1: THE EUROPEAN PINE SHOOT MOTH. Northeast. Logger 8(7): 20, 21, 50, 51; illus.

(Reviews status of the European pine shoot moth problem as well as research being conducted in Michigan on the shoot moth.)

* Heikkenen, Herman John. THE IDENTIFICATION AND DATING OF PAST ATTACKS OF THE EUROPEAN PINE SHOOT MOTH ON RED PINE. Jour. Forestry 58: 380-384, illus.

(By dating past shoot moth attacks, the length of an infestation can be determined. Population buildups and stand damage can be estimated, and infestations on different sites compared and the feasibility of control measures and timber stand improvement practices determined.)

* Heikkenen, H. J., and Miller, W. E. EUROPEAN PINE SHOOT MOTH DAMAGE AS RELATED TO RED PINE GROWTH. U. S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 83, 12 pp., illus. (Processed.)

(Contrary to earlier literature implications, European pine shoot moth populations do not always build up and cause damage in young red pine plantings. Also, high and damaging insect populations do not always persist. Red pine growing 15 inches or more per year in height were found to resist attack.)

Miller, William E. DISCOVERY IN MICHIGAN OF *ORGILUS OBSCURATOR* (NEES), A FOREIGN PARASITE OF THE EUROPEAN PINE SHOOT MOTH. Jour. Econ. Ent. 53: 318.

(The finding of this parasite affecting the shoot moth in southeastern Michigan suggests that it spread from Ontario where it had been released in previous years. Such natural spread indicates that the parasite is adapted to Michigan and that attempts to use it to suppress the shoot moth should be stepped up.)

* Miller, William E. THE EUROPEAN PINE SHOOT MOTH: RELATIONSHIP BETWEEN PROPORTION OF TREES INFESTED AND NUMBER OF INSECTS PER TREE. Jour. Forestry 58: 647-648, illus.

(Up to about 7 insects per tree, there is an exponential relationship between number of insects per tree and percentage of trees infested in shoot moth-infested pine plantations in the spring. At low insect population densities, therefore the percentage of trees infested can be used as an index of insect population level, and laborious counting of insects on trees avoided.)

Miller, W. E. SPREAD OF FOREST LEPIDOPTERA. No. Central Branch, Ent. Soc. Amer. Proc. 14: 11. (Abs.) (Processed.) 1959.

(Reviews the different spreading processes observed among forest Lepidoptera, especially dispersal by convectional currents associated with frontal weather.)

* Miller, William E. UNUSUAL OCCURRENCE OF THE VIRGINIA PITCH-NODULE MOTH, PETROVA WENZELI (KEARFOTT), IN CANADA (LEPIDOPTERA: OLETHREUTIDAE. Canad. Ent. 92: 879.

(A few specimens of *Petrova wenzeli* were discovered among much larger numbers of *P. albicapitana* specimens obtained by the Canadian Forest Insect Survey at several Canadian localities. The normal range of *P. wenzeli* is in the middle eastern United States. How the insect came to be in Canada is not known.)

* Miller, William E., and Arend, John L. EUROPEAN PINE SHOOT MOTH DAMAGE REDUCED ON SHEARED CHRISTMAS TREES. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 592, 2 pp. (Processed.)

(Removing the buds on new shoots of red, Scotch, and Austrian pines during late June, mid-July, and early August prevented infestation of 86 to 100 percent of the second crop of buds. Although such operations largely prevent annual damage by shoot moth on shoots treated, the treatment does not prevent the population from building up the following year.)

* Schmiege, Donald C., and Anderson, Gerald W. THE FOREST INSECT AND DISEASE SITUATION, LAKE STATES, 1959. U. S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 79, 18 pp., illus. (Processed.)

(A cooperative report based on surveys conducted by Federal, State, and private agencies in 1959.)

* Wilson, Louis F. REDUCING PULPWOOD LOSSES FROM BORER ATTACKS BY SHADING CONVENTIONAL PULP PILES. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 583, 2 pp., illus. (Processed.)

(Woodborers, especially *Monochamus scutellatus*, caused the most damage to balsam fir logs in northern Minnesota. Piles in a clearing were much more vulnerable to attack than those in the shade. Pulp sticks that cannot be sprayed with insecticides or peeled should be protected from attack by piling in the shade or by a slash cover.)

Forest Diseases

* Anderson, Gerald W. THE SEARCH FOR RESISTANCE TO CHESTNUT BLIGHT IN THE LAKE STATES. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 578, 1 p. (Processed.)

(A surprisingly large number of surviving chestnut trees have been reported in the Lake States. Some of these are producing viable seed. None of the trees examined so far have been infected by chestnut blight, but the probabilities are that they are escapees rather than resistant trees.)

* Anderson, Neil A. STALACTIFORM RUST ON JACK PINE IN MINNESOTA. Forest Sci. 6: 40-41.

(Alternate host inoculation tests proved that a stem canker found on jack pine in Minnesota is caused by the rust *Cronartium coleosporioides* (*Peridermium stalactiforme*). This is the first report of this rust east of the Great Plains in the United States.)

* Anderson, Ralph L., Joranson, Philip N., and Einspahr, Dean W. HYPOXYLON CANKER ON EUROPEAN ASPEN. Plant Dis. Rptr. 44: 132.

(Cankers caused by *Hypoxylon pruinatum* were found on *Populus tremula*. No previous reports of infection on this host in North America or western Europe were found. It has been reported in Russia. European aspen appears to be about as susceptible as the native *P. tremuloides*.)

* Jacobs, Rodney D. TOP-DYING OF YELLOW BIRCH, UPPER MICHIGAN, 1955-1959. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 585, 2 pp., illus. (Processed.)

(The top-dying of yellow birch in Upper Michigan, first reported in Technical Note 444 and later in Technical Note 527, had been gradually improving until 1959 when it became more widespread. The increase in top-dying was related to stand density, being more pronounced in the heavier cuttings.)

* Kessler, K. J., and Anderson, R. L. *CERATOCYSTIS COERULESCENS* ON SUGAR MAPLE IN THE LAKE STATES. Plant Dis. Rptr. 44: 348-350, illus. (Processed.)

(A fungus isolated from a declining hard maple in Michigan was identified as the hardwood form of *Ceratocystis coerulescens*. This is the first report of this pathogen in the Lake States region. At present there is no evidence that it is an important factor in the maple blight and maple dieback problems.)

* Schmiege, Donald C., and Anderson, Gerald W. THE FOREST INSECT AND DISEASE SITUATION, LAKE STATES, 1959. U. S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 79, 18 pp., illus. (Processed.)

(A cooperative report based on surveys conducted by Federal, State, and private agencies in 1959.)

Van Arsdel, E. P. CYCLOHEXIMIDE (ACTI-DIONE), A NEW TOOL IN WHITE PINE BLISTER RUST CONTROL. Univ. Wis. Forestry Res. Note 54, 2 pp. (Processed.)

(Summarizes present status of knowledge, indicating that this control method has proven effective on western white pine, but that it is too early to evaluate its effectiveness on eastern white pine.)

Van Arsdel, E. P., and Riker, A. J. BLISTER RUST FUNGUS INOCULATIONS ON WHITE PINES IN MIST CHAMBERS. (Abs.) Phytopath. 50: 657.

(Presents evidence that at least 48 hours of conditions favorable for infection are required before any appreciable amount of blister rust infection will occur on white pine.)

Fire

LaMois, Loyd. 1894 - FOREST FIRE FIGHTING - 1959. Minn. Conserv. Volunteer 23(134): 10-14, illus.

(A brief account in popular style of advances in forest fire fighting techniques in Minnesota.)

Forest Wildlife

* Krefting, Laurits W., and Arend, John L. EFFECT OF DEER BROWSING ON A YOUNG JACK PINE PLANTATION IN NORTHERN LOWER MICHIGAN. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 586, 2 pp. (Processed.)

(Excessive deer populations are capable of killing many young planted jack pine, retarding height growth up to one-half of its potential, and deforming trees so that they are of little value for timber products.)

Estimation of Timber Volume, Growth, and Yield

* Avery, Gene, and Meyer, Merle P. VOLUME TABLES FOR AERIAL TIMBER ESTIMATING IN NORTHERN MINNESOTA. U. S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 78, 21 pp., illus. (Processed.) 1959.

(Analyzes the use in Minnesota of aerial volume tables from other regions, presents a preliminary table for northern Minnesota, and suggests a method for integrating photo estimates and field measurements of timber volume.)

Forest Economics

* Sutherland, Charles F., Jr., and Williams, Ellis T. SOME ASPECTS OF FOREST TAXATION UNDER THE FOREST CROP LAW AND UNDER THE GENERAL PROPERTY TAX IN WISCONSIN. Land Econ. 36: 65-78.

(A study of forest taxation in northeastern and central Wisconsin in 1958 revealed that (1) in most cases the accumulated taxes under the Forest Crop Law at the end of the contract period would account for an excessive share of the expected net income from forest products, (2) forest land is assessed at a higher ratio of its full market value than is other land (confirming the results of earlier studies), (3) distance of the owner's residence from the tract had no significant effect on assessment, and (4) size and value of timber strongly affect assessment.)

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* Toole, Arlie W. OPPORTUNITY FOR NEW WOOD INDUSTRIES: THE LAKE STATES FOREST RESOURCE. Forest Prod. Jour. 10: 51-54, illus.

(The Lake States area has over 53 million forested acres. The increment rate is 1,200 million cubic feet annually; less than half is used. Intensive forest management and forest utilization would provide the base for a multi-billion-dollar industry.)

Forest Resources and Timber Production Statistics

* Findell, Virgil E., Pfeifer, Ray E., Horn, Arthur G., and Tubbs, Carl H. MICHIGAN'S FOREST RESOURCES. U. S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 82, 46 pp., illus.

(Reports the status of the forest resource as of 1954. Comparisons with the first survey made 20 years earlier show that timber growth has increased and young stands are more adequately stocked. Much more timber could be cut now from certain hardwood species, such as aspen, oak, paper birch, and soft maple, and from jack pine. Although the trend in total timber harvesting has been down in recent years, the trend of pulpwood cutting is up. About one-third of the timber products cut are exported to Wisconsin and other States.)

* Horn, A. G. LAKE STATES PULPWOOD PRODUCTION EXCEEDS 3 MILLION CORDS, 1959. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 588, 2 pp. (Processed.)

(Shows pulpwood production by species in Minnesota, Wisconsin, and Michigan, as well as imports by species from other States and Canada.)

* Horn, Arthur G. PULPWOOD PRODUCTION IN LAKE STATES COUNTIES, 1959. U. S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 85, 13 pp., illus. (Processed.)

(Compares pulpwood production and imports by States and species in 1959 with those of the previous year and 10 years ago. Shows 1959 production by species for the Forest Survey districts and counties in each of the three Lake States.)

* Morgan, James T. THE BUSINESS OF COUNTING TREES. Conserv. Volunteer 23(134): 38-42, illus.

(Discusses the need for periodic Statewide timber inventories and the uses of the results. Describes the line-plot and block-mapping methods used in the first and second Lake States surveys, and the proportional-sampling-with-permanent-plots method being used in the third Minnesota survey.)

Morgan, James T., and Dickerman, M. B. RETURN OF THE FOREST. Mich. Conserv. 29(1): 18-21, illus.

(Discusses in general terms the changes in forest conditions in northern Lower Michigan between 1936 and 1956, based on two Forest Surveys. Timber stocking has improved and timber volumes have increased in most species. Pulpwood use has increased rapidly.)

* Stone, Robert N. PRELIMINARY REPORT ON THE SURVEY OF FOREST PLANTATIONS IN NORTHERN LOWER MICHIGAN. Mich. Acad. Sci., Arts, and Letters Papers (1959 meeting) 45: 93-102, illus.

(Presents the major inventory information about plantations in northern Lower Michigan, including area, volume, and growth. Points out the impact of native tree overstories on plantation development.)

Timber Utilization and Marketing

* Boldt, Charles E., and Arbogast, Carl, Jr. CHARCOAL KILN OPERATION FOR IMPROVED TIMBER STANDS. Forest Prod. Jour. 10: 42-44, illus.

(By converting the low-value wood removed in thinning a northern hardwood second-growth stand to a higher value product, such as charcoal, the timber stand improvement operation may be carried out more economically. The relationship between labor and wood costs and the selling price of charcoal for the operation to break even is shown in a chart.)

* Lane, Paul H. WOOD CARBONIZATION IN KILNS. Forest Prod. Jour. 10: 344-348, illus.

(A study of the design and carbonization process for three small rectangular kilns—sheet metal, castable refractory, and cinder-concrete block, respectively—showed that good-quality charcoal can be produced consistently in the first two types of kilns.)

* Lane, Paul H., and Scheffer, Theodore C. WATER SPRAYS PROTECT HARDWOOD LOGS FROM STAIN AND DECAY. Forest Prod. Jour. 10: 277-282, illus.

(Winter-cut birch and maple logs deck-stored in north central Wisconsin under water sprays from April to October showed no decay or fungus stain. In unsprayed checks, rot penetrated into the ends of the logs an average of 8 inches, and stain an average of 30 inches.)

* Ward, James C., and Lane, Paul H. WATER SPRAYS WILL SHORTEN CHARCOAL COOLING TIME. U. S. Forest Serv., Lake States Forest Expt. Sta. Tech. Note 582, 2 pp., illus. (Processed.)

(A preliminary test was made in a 3-cord charcoal kiln on the Argonne Experimental Forest to determine the feasibility of reducing the post-burn cooling period with water sprays. It showed that 650 gallons of water sprayed intermittently on top of 2,100 pounds of charcoal lowered kiln temperatures from 900° F. to 200° F. in 4 hours. The total cooling time was 13 hours by this method as compared with an average of 60 hours by natural radiation.)

* Warner, John R., and Essex, Burton L. TRENDS IN THE WISCONSIN CHARCOAL MARKET. U. S. Forest Serv., Lake States Forest Expt. Sta., Sta. Paper 80, 22 pp., illus. (Processed.)

(Describes the increase in domestic charcoal sales by type of retail store and size of city. Briquetted charcoal is preferred over lump charcoal and the 10-pound package far outsold all other sizes.)

Taves, Marvin, Hathaway, William, and Bultena, Gordon. CANOE COUNTRY VACATIONERS. Univ. Minn. Agr. Expt. Sta. Misc. Rpt. 39, 28 pp., illus.

(Describes the composition of a sample of recreationists in the Basswood Lake-Ely area of the Superior National Forest and their attitudes toward management and facilities.)

Taves, Marvin, and Morgan, James. CANOE COUNTRY CAMPING—WHO, WHERE, WHY? Minn. Farm and Home Sci. 27(3): 3, 20, illus.

(Describes characteristics of a sample of 383 canoeists and campers in the Ely-Basswood Lake area of the Superior National Forest in 1958.)

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